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Subject: Deliverable Number 0018, Baseline Joint Experimentation Campaign Plan

Reference: Strategic Mobility 21 Contract N00014-06-C-0060

Dear Paul,

In accordance with the requirements of referenced contract, we are pleased to submit this Baseline Experimentation Plan for your review.

Your comments on this document are welcomed.

Regards,

Dr. Lawrence G. Mallon
Strategic Mobility 21 Program Manager

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Strategic Mobility 21
Baseline Joint Experimentation Campaign Plan
Contractor Report 0018

Prepared for:

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In fulfillment of the requirements for:

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Prepared and Submitted by:

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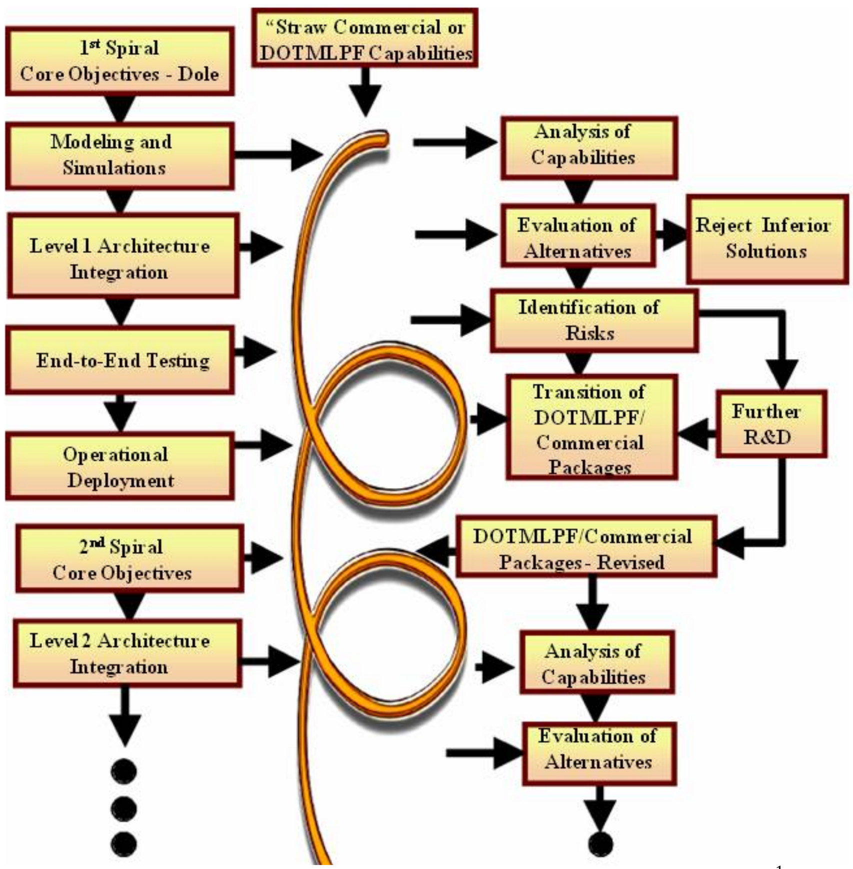
Abstract

This Technical Report establishes the initial Strategic Mobility 21 Joint Experimentation Campaign Plan. The plan is designed to support the deployment of the initial operating capability of the Joint Deployment and Distribution Support Platform (JDDSP). This initial plan is considered a living document that will be updated periodically during the program development effort. For long term experimentation planning, SM21 is following the general guidance provided by the Office of Force Transformation and US Joint Forces Command (JFCOM). Additionally, the guidance provided by the Focused Logistics - Joint Operations Concept (JOC); Joint Logistics (Distribution) Joint Integrating Concept (JIC); the Joint Sea Basing JIC; and the Sense and Respond Logistics JIC have been incorporated as appropriate.



SM21 Dual-Use System Spiral Development and Experimentation Process[1]

The near term experimentation plan and future campaign revisions will include discovery processes, scientific research and associated experimentation, limited demonstrations, and field demonstrations embedded in Joint Exercises. The experimentation plan is focused on deploying the commercial distribution management systems associated with the distribution mission capability package for the dual-use, prototype Joint Deployment Distribution and Support

[1] Adapted from: The Role of Experimentation in Building Future Naval Forces, Committee for the Role of Experimentation in Building Future Naval Forces, National Research Council, (2004), Figure 2.2 Spiraling in an experimentation campaign

Platform (JDDSP). The JDDSP will be developed and tested for experimentation at the Southern California Logistics Airport in Victorville, California. Experimentation will include projects that will enable the assessment of the JDDSP military utility for Joint Force Projection and Sustainment.

As depicted in the figure above, the campaign will support a spiral development of capabilities suitable for transition to the commercial sector and the Department of Defense (DoD). Requirements definition and experimentation planning and execution will include US Transportation Command (USTRANSCOM) and the US Joint Forces Command (USJFCOM) to support the development of the appropriate capabilities that will best benefit the Combatant Commands (COCOMS). The dual-use nature of the JDDSP requires that the commercial, public, and military requirements be considered. This includes, as depicted in the diagram, the military requirements associated with developing the doctrine, organization, training, materiel, leadership, personnel, and facilities (DOLTMPF) that together constitute the mission capability of a military force. As the figure depicts and this experimentation plan supports, the requirements of all sectors must be carefully blended into a cohesive system of systems design supported by a Service Oriented Architecture (SOA).

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1.0 INTRODUCTION

The Strategic Mobility 21 (SM21) program is in the process of developing an advanced distribution management concept named the Joint Deployment and Distribution Support Platform (JDDSP). The concept is based on a system-of-systems (SOS) architecture that is being designed to synchronize regional freight movement within the context of a Global distribution network. The JDDSP will provide regionalized, multi-modal distribution support to both the commercial and military sectors[2]. This technical report provides the experimentation campaign plan that will support the development of the prototype JDDSP. The prototype JDDSP will be developed for experimentation at the Southern California Logistics Airport (SCLA) located in Victorville, CA. This document SM21 establishes the basis for a continuous experimentation process to support both the concept refinement process and the development of the prototype JDDSP.

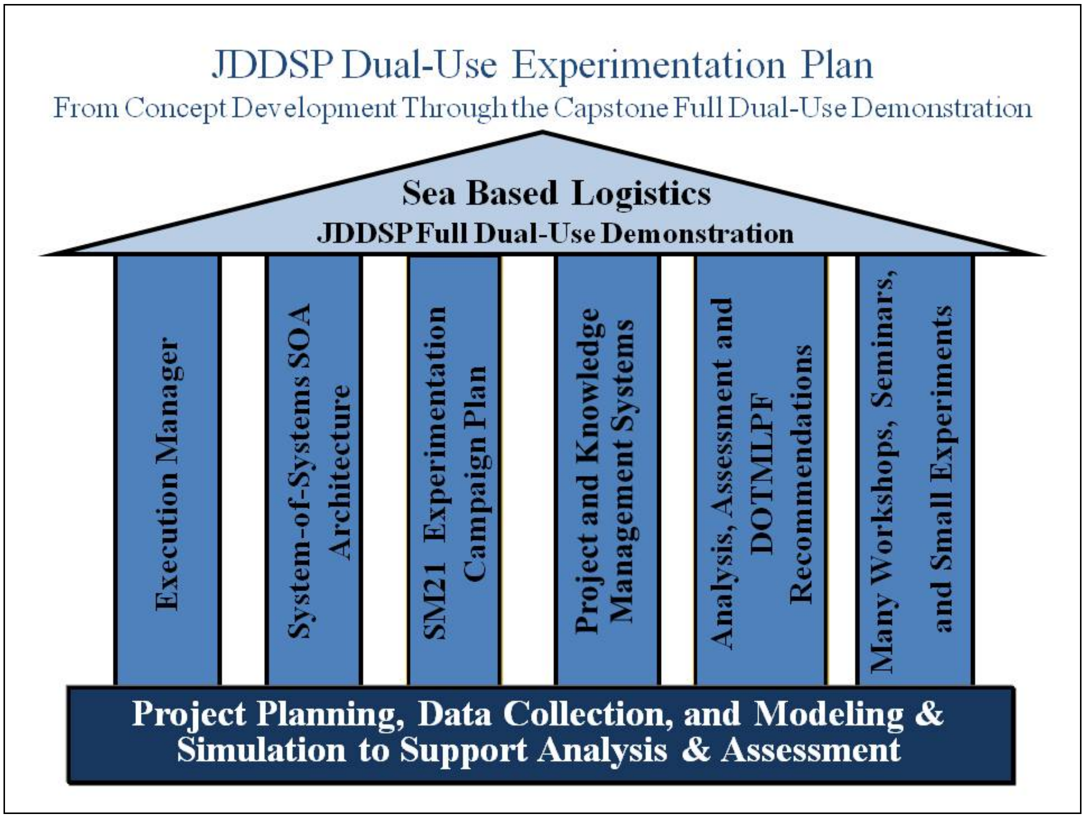

Figure 1: JDDSP Dual-Use Experimentation Plan Elements

Figure 1 provides an overview of the JDDSP continuous experimentation plan elements. As depicted, experimentation project planning along with modeling, simulation, and analysis create the foundation of the JDDSP experimentation plan. The experimentation process supports the development of the JDDSP planned capstone Sea Based Logistics support demonstration. The capstone demonstration is planned as an integrated element of a future Joint Training Exercise.

[2] The JDDSP is support capability is considered to be “dual-use”. This refers to the usability of the JDDSP by both the commercial and military sectors.

The supporting pillars of the experimentation process and the campaign plan are described in this report.

1.1 Military Logistics Support in a New Global Security Environment

In the multi-polar world that has replaced the bi-polar security environment since the end of the Cold War, the goal of the Department of Defense (DOD) is to maintain full-spectrum dominance against any potential adversary, nation state, or non-governmental organization. In order to achieve and maintain that level of dominance, a continuous process and information technology improvement program is required. To initially achieve full-spectrum dominance, DOD is engaged in a basic transformation process intended to exploit the inherent capabilities in new technologies and commercial business practices. That transformation extends to logistics through the focused logistics concept, which is defined as the ability to provide the joint force the right personnel, equipment, supplies, and support in the right place, at the right time, and in the right quantities (in the right sequence) across the full range of military operations.

The JDDSP is designed to support the demanding logistics requirements imposed by a multi-polar threat environment, including logistics support for complex humanitarian disasters. The JDDSP SOA architecture has been designed with the agility required to adapt to continuous changes in the threat and economic structure. As an example, the JDDSP design was recently required to adapt to the post container shipment import peak period that has transitioned rapidly into a carbon credit critical environment. Appendix C provides a detailed overview of the Joint Logistics (Distribution), Joint Integrating Concept (JIC) and the supporting role of the JDDSP.

1.2 The Strategic Mobility 21 Dual-Use Concept

The SM21 program is focused on developing or adapting the right dual-use technologies and best distribution practices to synchronize freight and military force movements within and between geographic regions. To achieve this level of agility and support, SM21 is adapting collaborative and continuous planning[3] and experimentation processes supported by knowledge management tools and agile development processes. This adaptive development and operational environment was established to create the agility required by a distributed network of regional dual-use multi-modal transportation and distribution support platforms or JDDSP.

The primary SM 21 program goals are to:

1. Support the transformation of DoD deployment and distribution logistics and regional commercial goods movement within the context of an end-to-end distribution network that may or may not be a part of a corporate or military supply chain logistics network.

2. Design and deploy dual-use transition JDDSP prototypes for military-commercial applications based on best commercial practices and the required capabilities and attributes established by the Focused Logistics Joint Functional Requirement

3. Design advanced project and knowledge management tools to support an advanced experimentation process that can be adapted by DoD or the commercial sector

[3] Continuous planning is also referred to in SM21 design documentation as “dynamic planning and replanning”.

As noted in the third program goal above, the development of the JDDSP will be supported by advanced project and execution management and experimentation processes. The initial SM21 Experimentation Plan and supporting experimentation processes are the focus of this technical report.

1.3 SM21 Three Year Experimentation Campaign

SM21 has developed an initial three year experimentation campaign focused on developing the dual-use capability of the JDDSP. Figure 2 provides a high-level overview of the initial campaign plan. The near term 2008 JDDSP IOC experimentation is detailed in Section 4.

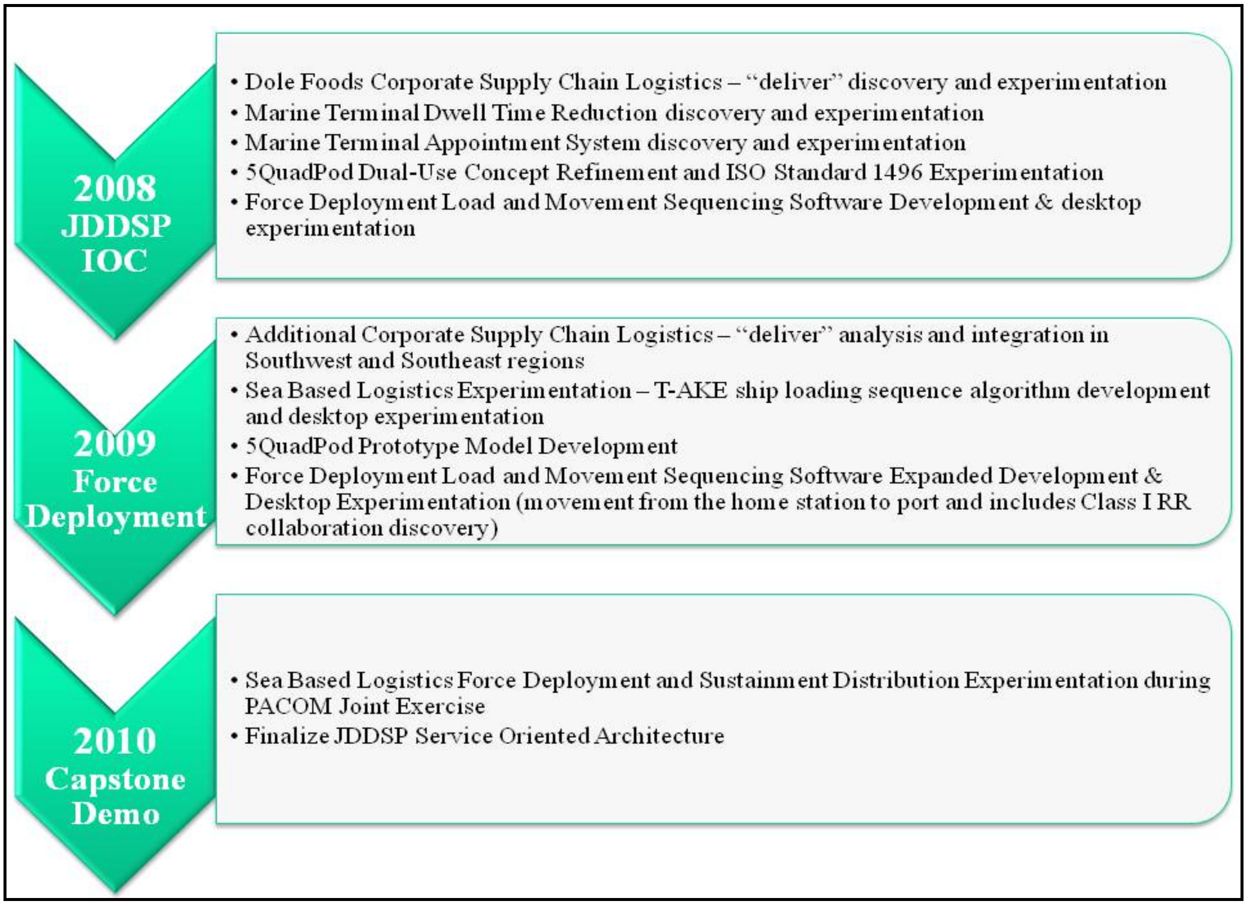

Figure 2: SM21 Experimentation Campaign Plan Overview

1.4 Organization of This Report

Section 1 above provided a general overview of the SM21 program, the JDDSP IOC development process, and the SM21 experimentation goals. The content of the remaining sections of this report are outlined below:

- Section 2 provides SM21 program background information
- Section 3 describes the JDDSP integrated development and experimentation process. It describes how the JDDSP will be developed through the execution of the initial experimentation plan. This section also provides a summary of the SM21 experimentation planning and execution process.

- Section 4 describes the near term experimentation opportunities and plans.
- Section 5 describes the initial commercial container freight movement optimization experimentation with Dole Foods designed to refine the SM21 experimentation process and support the development of the JDDSP IOC.
- Section 6 provides a description of the Container Appointment and Container Terminal Dwell Time Reduction experimentation
- Section 7 includes a description of the SM21 experimentation with advanced distribution packaging concepts.
- Section 8 begins the description of the JDDSP military capability experimentation. This section provides an overview of the proposed military experimentation campaign plan.
- Section 9 continues the JDDSP military capability description with an overview of the sea based logistics discovery campaign plan.
- Section 10 summarizes the experimentation technical report.

2.0 SM 21 PROGRAM BACKGROUND

2.1 An Integrated Solution Set

The SM 21 program is designed to provide an integrated solution set to the most critical issues facing both military force deployment and sustainment distribution and commercial intermodal logistics. This integrated solution is being designed to transform logistics networks into agile enterprises through the introduction of information technology based concepts and capabilities that promote total end to end visibility of shipment assets and individual items being shipped. This will require unprecedented levels of collaboration, data and information sharing in order to achieve the required dual-use end states in a secure and scalable environment. This level of collaboration will also support the mitigation of regional congestion while reducing community environmental impacts, and allow for the de-confliction of military-commercial goods movement.

Positive measurable outcomes during experimentation include: (1) a restored DoD capability to rapidly deploy from anywhere in the US using Southern California ports; (2) general de-confliction of DoD deployment with commercial import container movement; (3) a reduction in transit time through the region; (4) dynamic re-planning and in-stride shipment reconfiguration capability to balance changing commercial and military shipment priorities; (5) maximizing Southern California import container throughput in support of the national economy while mitigating adverse environmental and community impacts associated with trade induced growth; and (6) increased throughput velocity, visibility, efficiency in the use of surface transportation infrastructure, public safety and security of regional distribution networks.

2.2 Effects Based Outcomes

Long term success would ensure the most efficient movement of goods throughout the supported region, to include during periods of crisis, as well as meeting demand generated growth. SM 21 will bring greater visibility of goods movement, resulting in quicker turns for conveyances and increased productivity as asset utilization would be optimized. As movement visibility is increased, so is the ability to make informed decisions concerning routing and traffic flow. This reduces congestion and increases cargo velocity. The enhanced visibility tools provide the means to secure shipments transiting the regional distribution network. The region benefits from the reduced congestion and proportional reduction in emissions as vehicles idle less in traffic, and cargo is moved on the most efficient mode as determined by the JDDSP "state of the industry" transportation management systems. One desired effects based outcome is the ability to employ the Port of Long Beach as a military strategic sea port[4] with minimal or no impact on commercial commerce.

The operational parameters by which the SM21 JDDSP dual-use utility will be assessed during the development and experimentation period will include the degree to which the JDDSP capabilities achieve the following:

- Improved access to accurate and relevant force deployment, sustainment distribution, and

[4] The regional port complexes in Long Beach, Los Angeles, and San Diego, as designed strategic ports, have been issued Port Planning Orders (PPO) by the Department of Transportation, Maritime Administration

commercial distribution logistics information,

- Accurate and relevant military and commercial distribution logistics information to a broader array of stakeholders through the web enabled environment,
- Improved user distribution logistics situation awareness and execution decision making ability,
- Improved ability to collaborate on distribution logistics planning, dynamic replanning and execution of selected tasks.

The operational parameters outlined above will be assessed using the Performance Based Evaluation Metrics outlined in Appendix C.

2.3 Joint Deployment Distribution Platform Integration with the Agile Port System

Where appropriate, the JDDSP can be the dual-use inland port component of the Agile Port System (APS) concept designed by the Center for the Commercial Deployment of Transportation Technologies (CCDoTT). The JDDSP concept incorporates a dual-use capability designed to help manage and de-conflict inbound commercial shipments and outbound military force deployments. The SM21 Initial Capabilities Document (ICD) envisions a dual-use inland terminal facility with scalable multi-modal physical and information technology infrastructure designed to close capability gaps.

The JDDSP can also be thought of as a super-node in the global logistics network. In the physical domain, it is characterized as an inland port and multi-modal transfer facility or hub operating under a common operating system to synchronize throughput and services to multiple stakeholders. This includes operation as an intermediate node between military Power Generation Platforms and Sea or Aerial Ports of Embarkation. In this context the JDDSP would support the marshaling and staging of forces for just-in-time call forward for synchronized strategic air and surface transport loading. In the information domain, it is one node among a family of super-nodes within the Joint Deployment Distribution Enterprise (JDDE) global logistics network as overviewed in Figure 3.

SM21 recognizes the importance of the Ports of Los Angeles and Long Beach (POLA/POLB) to DoD and the regional and national economy. Therefore, SM21 recognizes the importance of commercial, public, and DoD participation in the JDDSP requirements development and experimentation process to reduce or eliminate the current conflicts between military and commercial activities at strategic ports. These conflicts have discouraged DoD form using certain port complexes for deployment and distribution operations.

In general, military planners recognize the need to assure DoD access to strategic ports. This is particularly true with the emphasis on military transformation and the increased reliance on force projection capabilities from the United States. The JDDSP represents an opportunity for DoD to partner in the development of future dual-use distribution management capability. As a dual-use capability, the JDDSP is a transformational enabler to help achieve Joint Vision 2020 deployment and distribution capabilities.

The JDDSP systems of systems architecture leverages many current concepts and infuses them with the DoD Joint Functional Concept capabilities. This is being made possible through the use of emerging technologies and processes to change the focus of force projection operations from a sequential, linear process to more flexible and responsive concurrent processes that can be dynamically planned and re-planned. This new capability is designed to effectively support the war-fighter responsible for executing expeditionary operations.

Until recently both military planners and commercial distribution management systems focused distribution network planning on a segment-by-segment and sequential-linear basis and not as an integrated, end-to-end network centric environment. This has led to a number of logistics challenges that still require resolution such as: cargo shrinkage, lack of end-to-end process/product visibility, redundant ordering of supplies, lack of operational flexibility, and mission degradation. The SM 21 strategy is to design, simulate, build, experiment, and demonstrate components of a prototype logistic smart node (JDDSP) that will solve most issues by fully leveraging network centric logistics technologies and assets.

3.0 JDDSP INTEGRATED DEVELOPMENT AND EXPERIMENTATION PROCESS

SM21 has initiated a multi-year JDDSP development project using agile, evolutionary development processes that will be supported by this experimentation campaign plan. This technical report is considered a living document. The experimentation campaign plan, following the agile evolutionary development process, will require adjustment as development and experimentation proceeds. The requirement for this flexibility was highlighted during a recently completed Independent Verification and Validation (IV&V) of the JDDSP system-of-systems (SOS), service oriented architecture (SOA). As a result of the IV&V, changes in the JDDSP architecture were required to correct several shortfalls including security and scalability issues. "Getting it right" upfront and keeping the concept and system development on track requires a supporting experimentation campaign. For SM21 the purpose of the experimentation plan is to develop and test the IOC of the JDDSP. As a dual-use program, near term experimentation will support a few of the joint military distribution requirements but will concentrate on commercial distribution management capabilities[5] since the commercial transportation system will be the backbone of the JDDSP.

The near term experimentation planning and development process is detailed in the following sections of the basic technical report. The SM21 Long Term Joint Experimentation Strategy is defined in Appendix H of this report.

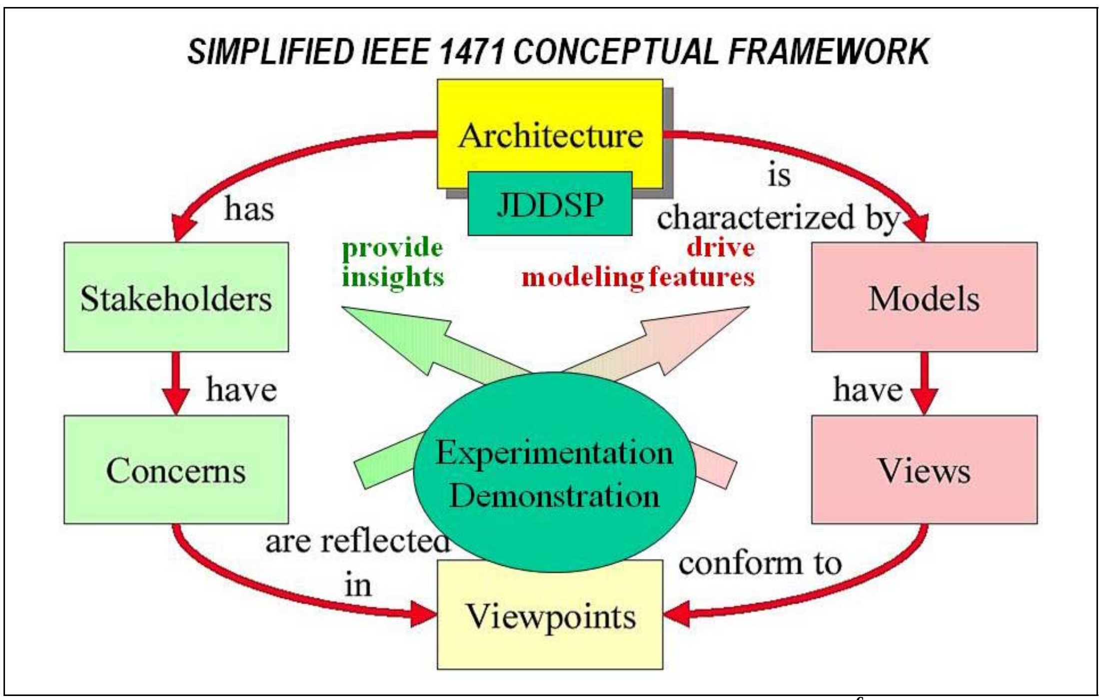

Figure 3: Role of Experimentation and Demonstration[6]

[5] This philosophy is supported by the Phase I Report of the Defense Science Board Task Force on Joint Experimentation, September 2003, p. 13

[6] System-of-Systems Architecting: The Role of DoDAF Views, a brief to Strategic Mobility 21, Ken Cureton, June 22, 2007

3.1 SM21 Experimentation Strategy

The SM21 Experimentation Strategy is designed to guide the development of the JDDSP IOC dual-use capabilities. The near term experimentation strategy is focused on the development of the JDDSP regional capabilities, which are primarily commercial distribution management. A progressive series of joint commercial and military collaborative workshops, modeling and simulation, and capability deployments to support micro-experiments and demonstrations are included in the near term SM21 experimentation plan. Figures 1 and 2 provide a visual overview of the scope of this plan.

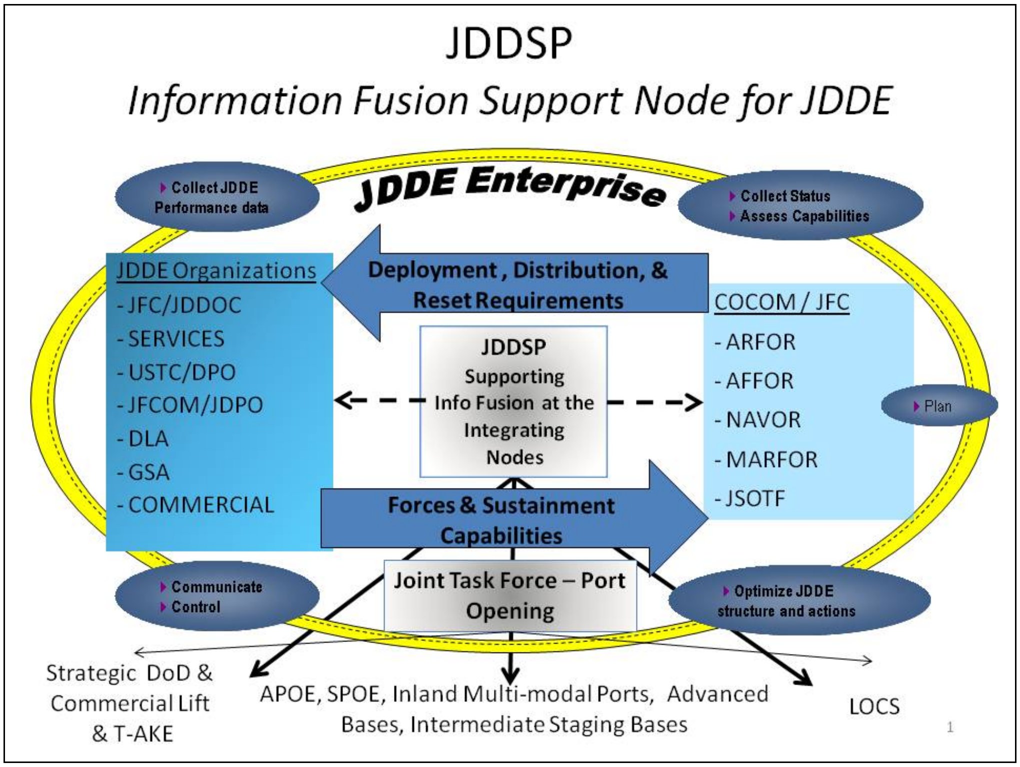

Figure 4: JDDSP Support of the Joint Deployment and Distribution Enterprise

Delays in the end-to-end supply chain system are normally the result of a lack of shipment visibility at regional distribution transition points. As an example, container drayage operations between ocean terminals and inland transshipment points are often information “black holes” within track and trace support systems. Overall, visibility gaps are most commonly the result of a lack of tracking technology, incomplete or non-existent data sharing among distribution network stakeholders, and ineffective “off-line” coordination. Figure 3 provides an overview of the JDDSP capability development process being adapted by SM21 and the role experimentation will have in identifying and closing visibility gaps. As depicted in Figure 3, SM21 intends to fully integrate experimentation with the JDDSP architecture design and development process. As an example of this integrated process, the initial JDDSP shipment tracking and support functionality will be developed based on the requirements discovery and experimentation project conducted jointly with Dole Foods. The Dole Foods experimentation project is detailed in Section 5 of this report. The experimentation project is designed to provide Dole Foods with the appropriate shipment visibility and planning tools to enable the continuous optimization of their regional supply chain. For SM21 it will be a discovery process for determining what is needed to provide the required services to support corporate supply chain logistics “deliver” functions.

While early experimentation supports the development of the JDDSP dual-use regional commercial requirements, this initial plan also outlines future experimentation associated with developing the capabilities required by Joint Deployment and Distribution Enterprise (JDDE). The potential integration of the JDDSP with the JDDE is depicted in Figure 4. The JDDE is a global community of interest and practice responsible for joint force deployment, agile sustainment, and global commercial transportation and distribution.

The JDDSP architecture will support data and information fusion at the distribution integrating nodes. During the experimentation and design refinement phases of this project, it is important to remember that the JDDSP architecture will support operations at all major JDDE distribution nodes including aerial ports, seaports, multi-modal inland ports, and military transshipment points such as Advanced Bases and Intermediate Staging Bases. This will require careful analysis, modeling, and experimentation to ensure that the support requirements for each node are properly identified and developed.

As depicted below in Figure 6, the initial experimentation with Dole Foods will require the deployment of approximately 20% of the total estimated full operating capability of the JDDSP, which is composed of the Inland Port Multi-Modal Terminal Operating System (IP-MTOPS) and the Integrated Tracking System (ITS) concepts. The IOC will enable the basic functions of both systems.

Before and during the continuous experimentation process with Dole Foods, the following JDDSP containerized freight management functions will be deployed:

- Visibility of shipments across modes (shipments across rail, truck, with air as a future addition)
- Regional shipment visibility (visibility of queuing and tracking)
- Tracking purchase orders (PO) or material release orders (MRO) from receipt to delivery.
- Shipment visibility granularity to the item level (when data is available).
- Visibility into staging areas, warehouses, and trans-loading locations.
- Initial integration of commercial and military tracking data
- Least cost path analytical calculation considering cost and required delivery date
- Visibility of shipper agreements with each carrier
- Initial collaborative planning capability
- Alerts, reports and notifications
- Monitoring of the quality of freight services and condition of transport assets.

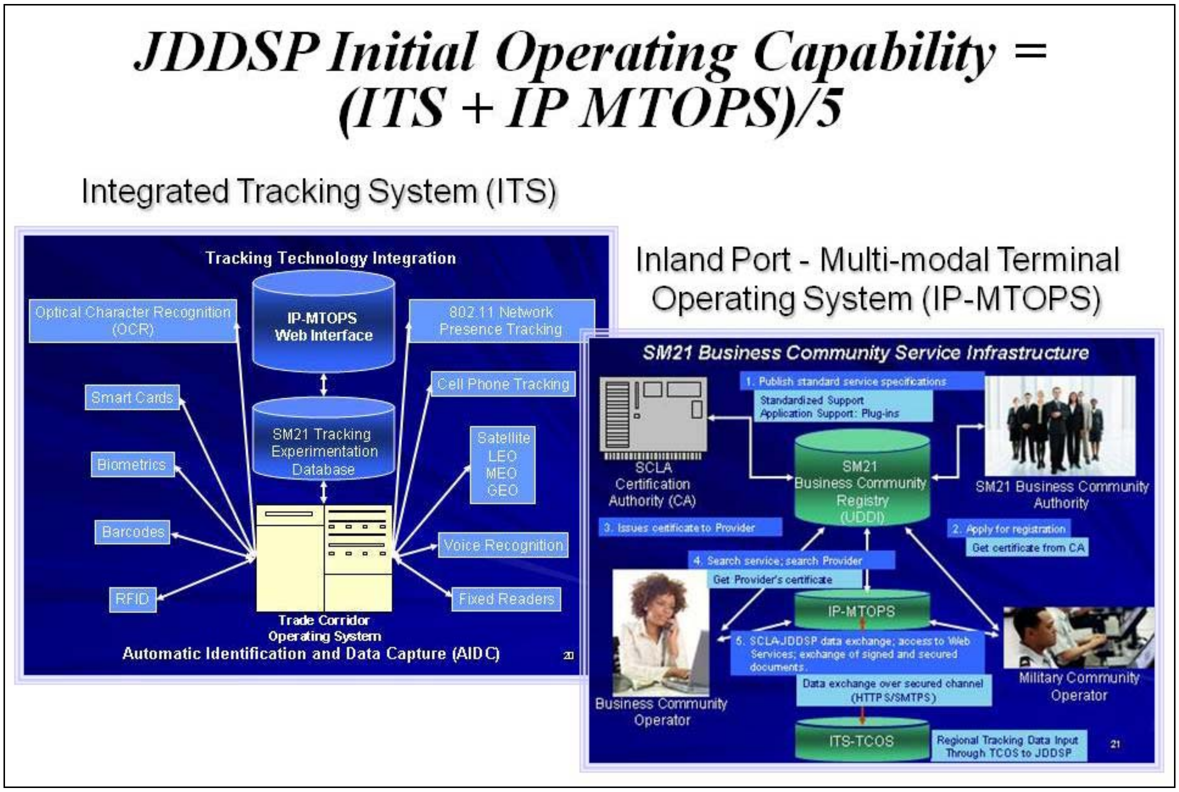

Figure 5: JDDSP Initial Operating Capability

3.2 Experimentation Defined in the Context of the SM21 Program

The near term SM21 experimentation campaign plan supports the deployment of the basic JDDSP services. After the JDDSP initial operating capability (IOC) comprised of basic container track and trace functions is achieved, the Dole Foods distribution network will be "on-boarded" using a standard commercial business process. The initial data feeds for tracking Dole shipments will be limited to imports of specific canned pineapple products. Once the Dole Foods initial data is "on-board" the JDDSP operating system, the joint SM21-Dole Foods experimentation plan will begin execution. As previously noted, this joint experimentation will be used to support optimization experimentation associated with the Dole Foods supply chain deliver functions within Southern California and will support the continued development of the JDDSP IOC.

Since both future military and near term commercial experimentation will be addressed in this technical report, it is important to provide some basic definitions associated with the experimentation process. In the military context, the following relatively broad definition of the term "experimentation" will be adapted: *Military experimentation is a military activity conducted to discover, test, demonstrate, or explore future military concepts, organizations, and equipment and the interplay among them, using a combination of actual, simulated, and surrogate forces and equipment.*

The definition highlights the fact that building future capabilities through experimentation means more than acquiring new equipment and systems. Building tomorrow's military distribution and force deployment capabilities means developing the doctrine, organization, training, materiel, leadership, personnel, and facilities (DOLTMPF) that together constitute the mission capability of a military force. If experimentation is to be useful, it must deal with all these elements of capability.

The outline below provides the generally accepted definitions for each DOTMLPF element[7].

- Doctrine: Fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application.
- Organization: how we organize to fight; divisions, air wings, Marine-Air Ground Task Forces (MAGTFs), etc.
- Training: how the military prepares to fight tactically; basic training to advanced individual training, various types of unit training, joint exercises, etc.
- Materiel: all the "stuff" necessary to equip military forces, that is, weapons, spares, etc. so they can operate effectively.
- Leadership and education: how the military prepares leaders to lead the fight from squad leader to the general/admiral officer ranks; continuous professional development.
- Personnel: availability of qualified people for peacetime, wartime, and various contingency operations.
- Facilities: real property; installations and industrial facilities (e.g. government owned ammunition production facilities) that support our forces.

The general experimentation or scientific method defines the overall body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. It is based on gathering observable, empirical and measurable evidence[8]. As is generally known, scientific experimentation includes the collection of data through observation and formal collection processes, and the formulation and testing of hypotheses. Although procedures vary, certain core features distinguish the scientific process from other methodologies of developing knowledge. Scientific research employs hypotheses as explanations of phenomena, and design experimental studies to test these hypotheses. These steps must be repeatable in order to predict dependably any future results. Theories that encompass wider domains of research such as regional distribution may bind many hypotheses together in a coherent structure. This in turn may help form new hypotheses or place groups of hypotheses into context. The SM21 methodology for formulating and testing hypotheses is located in Appendix B.

Among other facets common to the scientific research process are:

- The conviction that the process must be objective to reduce a biased interpretation of the results.
- The expectation that the experiment, process, and all data will be documented; archived; and shared so it is available for careful scrutiny by all stakeholders. This practice, called full disclosure, also allows statistical measures of the reliability of these data to be established[9].

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[7] CJCSI 3170.01E and CJCSM 3170.01B, Definitions summarized from https://akss.dau.mil/askaprof-akss/qdetail2.aspx?cgiSubjectAreaID=9&cgiQuestionID=19945
[8] SM21 will gather most of its measureable evidence from data collected by the JDDSP IOC.
[9] From Wikipedia, Scientific Method definition, located at: http://en.wikipedia.org/wiki/Scientific_method

SM21 experimentation will not be an end unto itself and will not merely be a means for pursuing a few interesting ideas. It is intended to build future commercial and military capabilities. SM21 experimentation must support learning what systems are best suited to serve the distribution needs of shippers, terminal operations, and mode operators in the region served by the JDDSP. SM21 will support continued development of a knowledge management system to share the knowledge gained through experimentation. Experimentation must support exploring the potential value of new services and new business processes to enable SM21 program and technical managers to make informed decisions about improving distribution in the region[10].

3.2.1 Future Joint Military Experimentation

Joint military experimentation is the heart of logistics transformation for DoD. Joint Warfighting Experimentation includes analysis, simulations, war-games, experiments, Joint or Advanced Concept Technology Demonstrations (JCTD's/ACTDs), joint exercises conducted in virtual and field environments, and red team vulnerability assessments. To support the transformation process, the capstone SM21 JDDSP experiment will be imbedded in a Joint Exercise currently in the preliminary exploration stage with the Pacific Command (PACOM). One goal of this joint experiment planning process will be to support the refinement of JFCOM processes for developing and updating their Joint Innovation and Experimentation Campaign Plan. The long term military campaign strategy is defined in Appendix H.

3.2.1.1 Military Experimentation Definitions

The definition of the term "experimentation" in the military context is not consistent. The Joint Chiefs of Staff (JCS) Publication 1, the DOD's source for standard definitions, does not define it. The U.S. Joint Forces Command's glossary defines "joint experimentation" as the "application of scientific experimentation procedures to assess the effectiveness of proposed (hypothesized) joint warfighting concept elements to ascertain whether elements of a joint warfighting concept cause changes in military effectiveness[11]." This definition is relatively narrow considering both the purpose of joint experimentation and the range of methods available and employed.

In *Code of Best Practice for Experimentation*, co-author David Alberts, director of research and strategic planning of the Office of the Assistant Secretary of Defense, presents three types of experiments, each having a different purpose[12]:

- *Discovery experiments* are conducted "to determine the efficacy of something previously untried."
- *Hypothesis-testing experiments* are used to advance knowledge by "seeking to falsify specific hypotheses."[4]
- *Demonstration experiments* recreate known truth to "display existing knowledge to people unfamiliar with it.

[10] The Role of Experimentation in Building Future Naval Forces, Committee for the Role of Experimentation in Building Future Naval Forces, National Research Council, (2004), pp 28-29.
[11] Joint Forces Command Glossary, located at http://www.jfcom.mil/about/glossary.htm#J
[12] The Role of Experimentation in Building Future Naval Forces, Committee for the Role of Experimentation in Building Future Naval Forces, National Research Council, (2004), pp 29-30.

Joint experimentation is generally an iterative process of collecting, developing and exploring concepts to identify and recommend better value-added solutions for changes to Doctrine, Organization Design, Training, Materiel, Leader Development, Personnel, and Resources required to achieve significant advances in future joint operational capabilities. Joint experimentation is the linchpin of DoD's strategy for transformation.

The objectives of joint experimentation are to develop and refine innovative concepts of operation and co-evolve mission capability packages into real operational capabilities. An experimentation campaign is a series of related activities that explore and mature knowledge about a concept of interest.

3.2.2 Capability Based Planning and Joint Military Experimentation

In DoD's capabilities-based planning (CBP) process, joint concepts link strategic guidance to the employment and development of future joint force capabilities and serve as "engines for transformation". In general terms, a concept is a notion or statement of an idea—an expression of how something might be done. A joint military concept is a visualization of future operations that describes how a commander, using military art and science, might employ capabilities to achieve desired effects and objectives. It need not be limited by current or programmed capabilities.

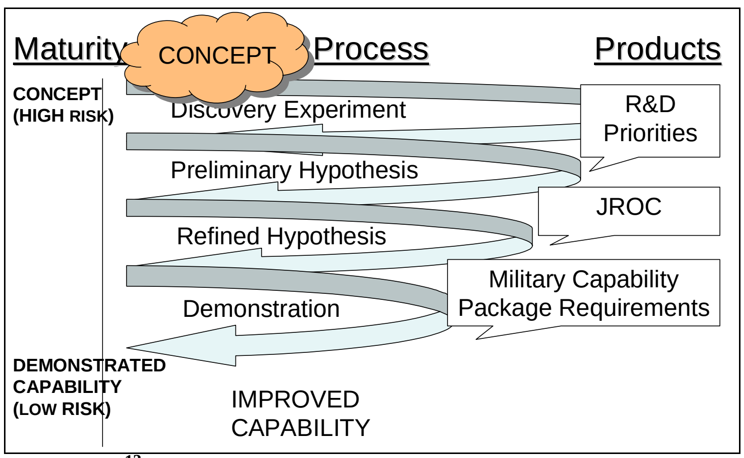

Figure 6[13]: Capability Development: Theory to Development

To be useful, joint concepts must describe a particular military problem and propose a solution supportable by logic and investigated through experimentation. The central and supporting ideas should be clear, concise statements that assert specific actions that will result in specific desired outcomes. These actions and their outcomes should be explored in experimentation.

Joint Experimentation is used for two purposes: (1) to develop and refine concepts in a rigorous competition of ideas; and (2) to investigate solutions to identified capability gaps. It is unlikely that experimentation can test an entire joint concept at once. Rather, an approved joint concept is a living document that will be revised incrementally as individual aspects are either incorporated

[13] David S. Alberts, Richard E. Hayes, John E. Kirzl, Leedom K. Dennis, and Daniel T. Maxwell. 2002. Code of Best Practice Experimentation, DOD Command and Control Research Program, Office of the Assistant Secretary of Defense (Networks and Information Integration), Washington, D.C., July, Ch. 3., p. 26, Figure 3.1

into DOTMLPF changes or invalidated and replaced. Figure 6 provides a visual representation of the evolution of a capability from a theory or concept to an improve war fighting capability.

4.0 SM21 NEAR-TERM EXPERIMENTION PLANNING

The remainder of this report will present the near term experimentation opportunities and processes to be followed. Currently four major stakeholders have agreed in principle or by a written agreement to collaborate with SM21 on the major experiments outlined in Figure 7 immediately below and Table 1 located at the end of Section 4.

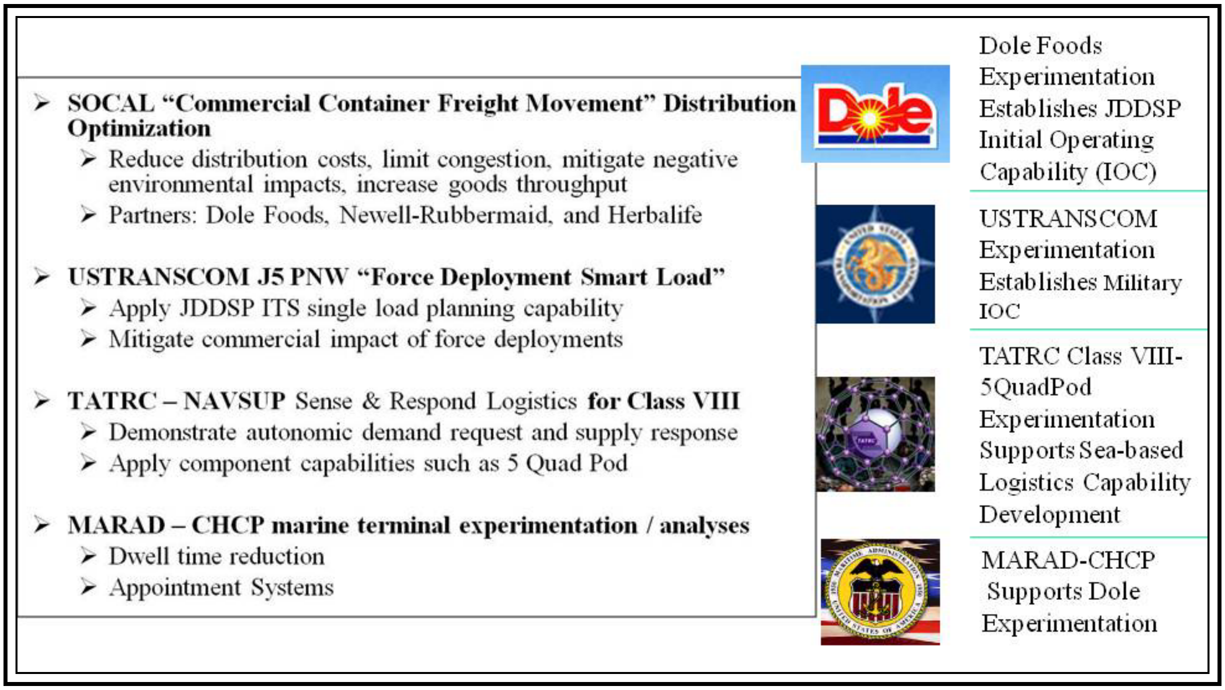

Figure 7: Near Term Experimentation Overview

Each experiment outlined in Figure 7 will have its own detailed experimentation execution plan (project management plan) developed after all stakeholder and participant agreements are finalized. Each of the four experiments is overviewed in this report after the general experimentation process for all SM21 experimentation is outlined below. The primary elements of the baseline experimentation and the planned SM21 ongoing experimentation campaign process are depicted in Figures 8 and 9.

4.1 Near Term Experimentation Approach

Each of the experiments will have a separate experimentation project management plan (PMP) developed and approved by the functional and technical committees. The PMP for each experiment will be maintained on the SM21 Project Management Information System (PMIS) managed by the SM21 Project Management Office (PMO). Formal planning will begin after the appropriate commercial or government stakeholders signs a formal commitment in the form of a Memorandum of Agreement (MOA), Memorandum of Understanding (MOU), or other appropriate agreement. The agreement will contain the level of effort and cooperation required by SM21 and the other stakeholders to complete the experiment along with the defined roles and responsibilities for each stakeholder.

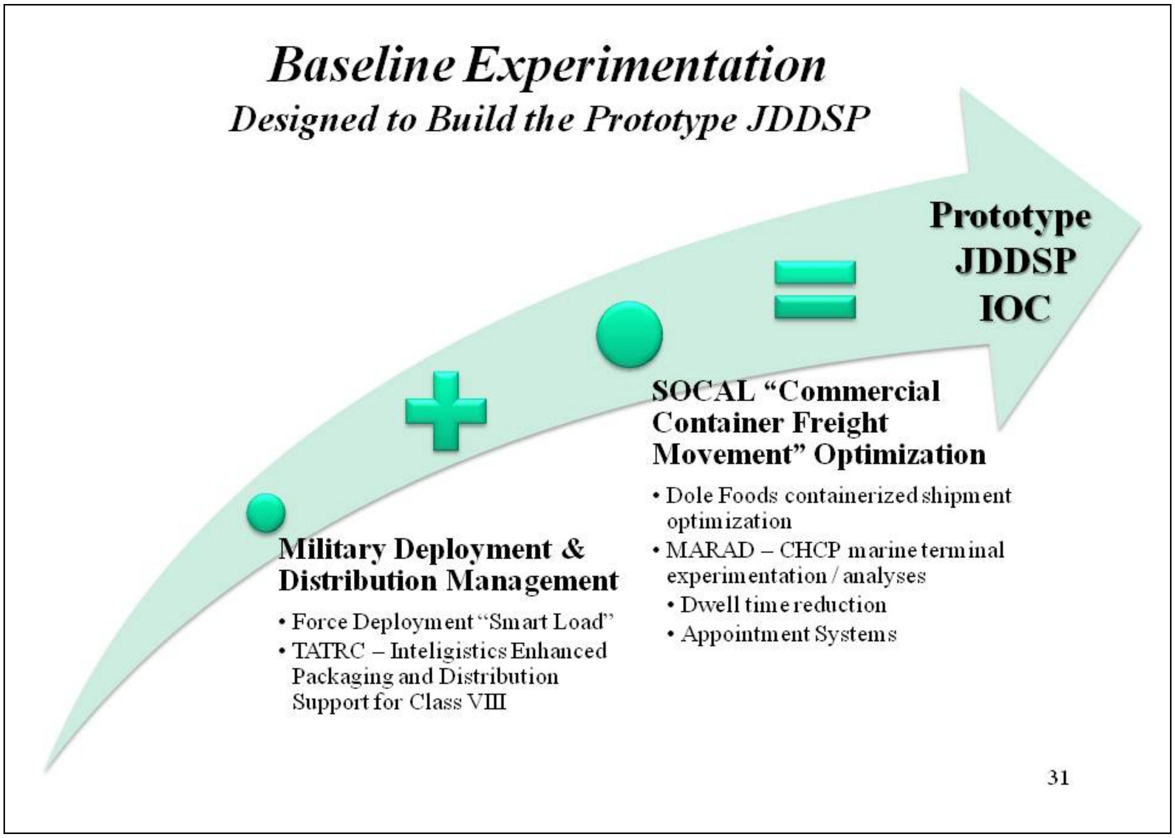

Figure 8: Baseline Experimentation Overview

Following the signing of the experimentation agreement (MOA or MOU) and the completion of contracting with the experimentation partners, the experimentation PMP will be developed using this document and the Project Management Institute (PMI) standards adapted by SM21. The PMP will outline the experimentation methodology, tasks, and associated timelines for all stakeholders directly participating or impacting the experiment. Each near term experiment will be focused on the development of the prototype JDDSP supporting the Southern California Logistics Airport.

4.2 SM 21 Joint Experimentation Organizational Structure

Under the overall leadership of the program managing director, the SM21 team will utilize a matrix organizational structure to establish each of the experimentation project teams. When practical, a dedicated project/execution manager will be responsible for the demonstration project leadership and execution management. Working with a technical team, the project manager will assume direct responsibility for developing the project plan with the SM21 Project Management Office (PMO), leading the experimentation team, and managing the completion of all analysis and technical reports.

A technical team headed by the SM21 Chief Systems Architect will support the project manager. The technical team will be responsible for reviewing and recommending changes to the experimentation plan design and project plan. A counterpart functional team, under the leadership of the Chief Technology Officer (CTO), will support the experimentation project manager by defining the user requirements, business process documentation of the baseline "As-

Is" state, and developing the data collection plan for modeling the as-is and to-be process. The Functional team will also develop and complete customer validation surveys and identify capability gap/seam analysis by completing a To-Be (SCOR) analysis when applicable to the experiment.

4.3 SM21 Experimentation Planning and Execution

SM21 Experimentation Planning and Execution consists of three sets of integrated sequential processes:

- The Experimentation Preliminary Planning Process (Figure 10)
- The Experimentation Execution Planning Process (Figure 11)
- The Experimentation Execution Process (Figure 12)

The SM21 experimentation preliminary planning process is outlined Figure 10. As depicted, experimentation planning begins before the signing of agreements and the development of a project management plan. The first step in experimentation planning for SM21 will be the identification of preliminary capability gaps that require, or could be supported, by an experimentation process to "close the gap". This preliminary gap identification process will be completed through direct collaboration with commercial and military distribution stakeholders.

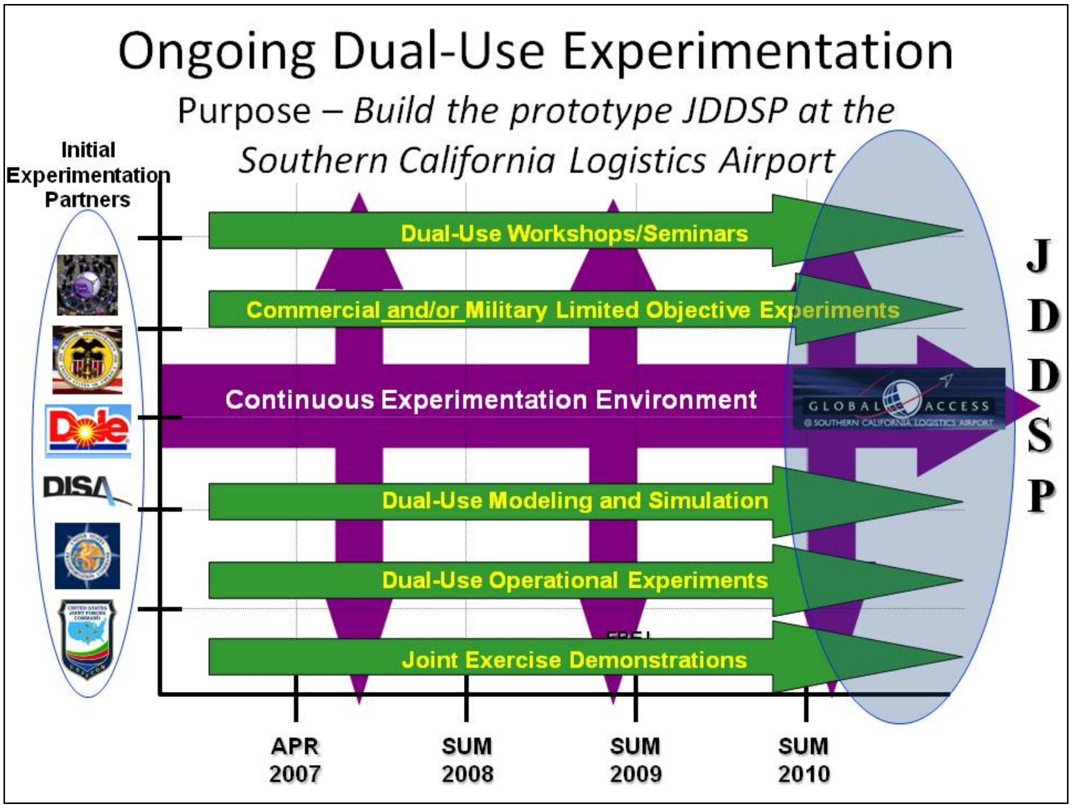

Figure 9: Ongoing Dual-Use Experimentation Plan

As has been completed for the planned future force deployment demonstration, a baseline process analysis and data collection must be completed prior to the initiation of execution planning. This baseline analysis is required to identify capability gaps that must be that must be included in the experimentation plan.

The Execution Planning Process outlined in Figure 11 will initiate formal experimentation planning. This process begins with the development of the PMP followed by data collection, modeling and simulation, and the analysis of results. The process for conducting formal experimentation is defined in Appendix B. The general experimentation planning will follow the steps outlined in Figure 10 and augmented below:

- Begin with a stakeholder planning meeting,
- Development of the PMP and finalization of the experimentation method,
- Establish the data collection and scenario development plan
- Baseline data collection
- Conduct current state or as-is process modeling to validate the models and establish the baseline
- Model the future state or to-be conditions for each major and minor experiment planned

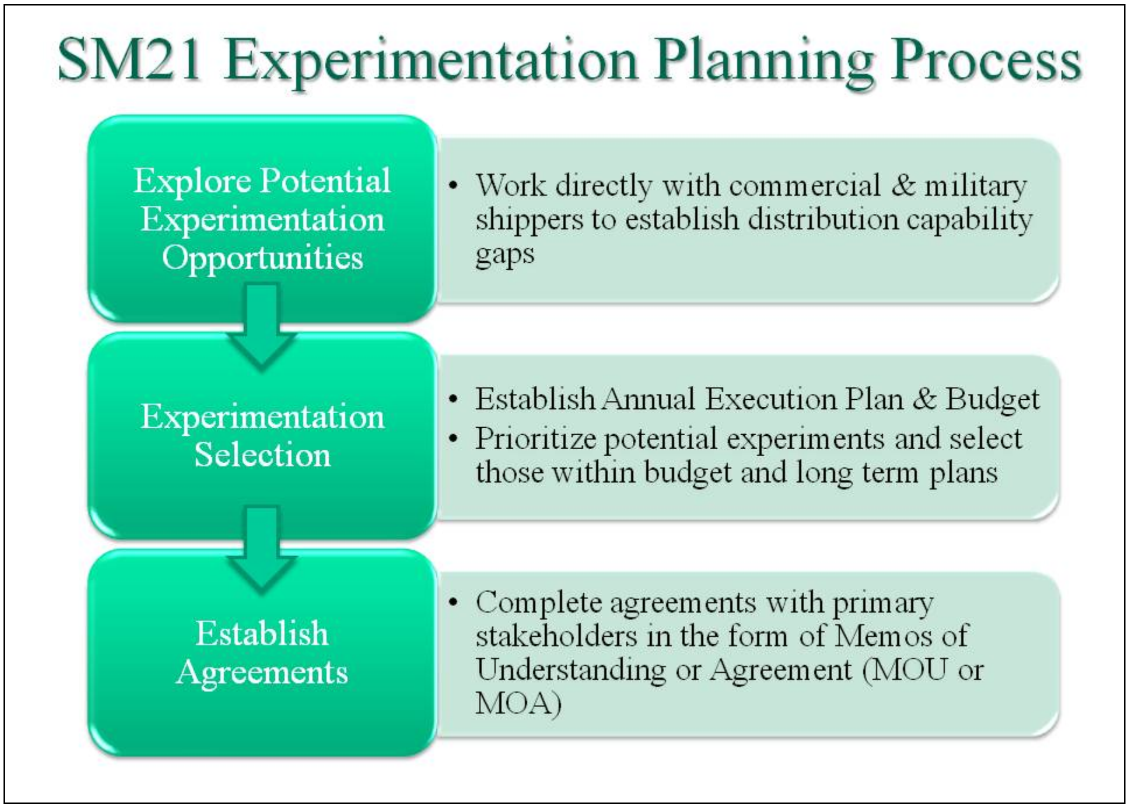

Figure 10: SM21 Experimentation Planning Process

Once steps outlined in Figure 11 are completed, the Experimentation Execution Process will begin as depicted in Figure 12.

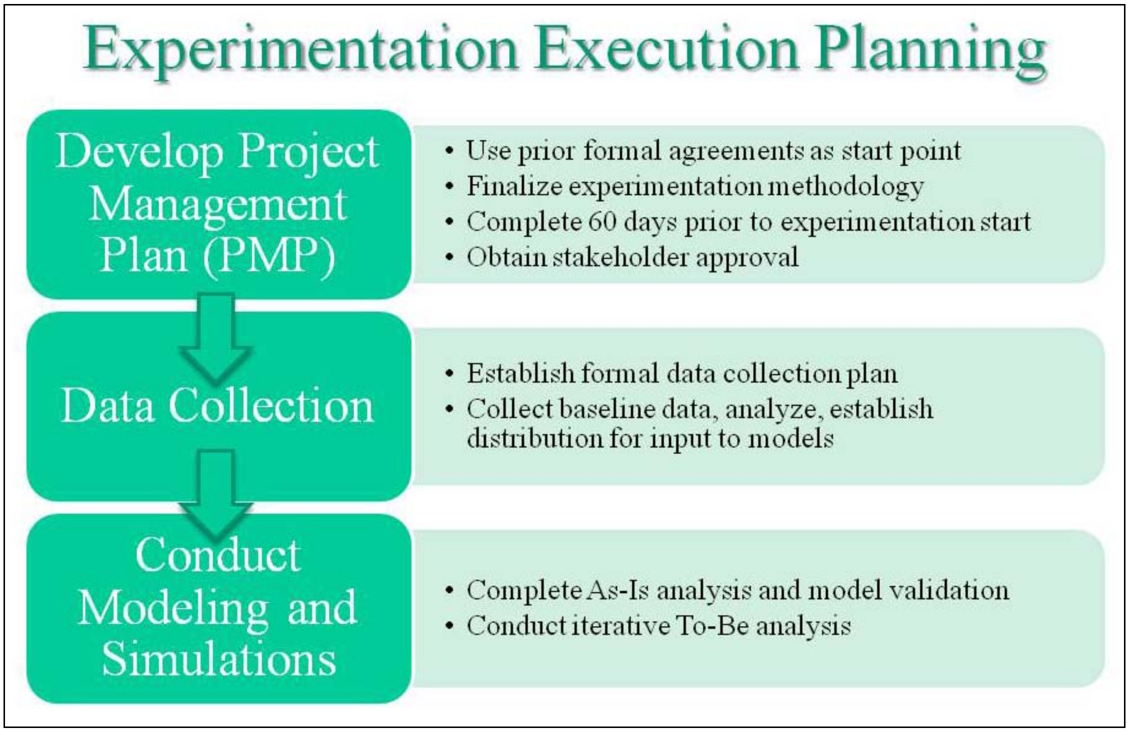

Figure 11: SM21 Experimentation Execution Planning

The Experimentation Execution Process is represented in Figure 11 as an experimentation "context diagram" using the IDEF0 Process Modeling approach. The details of the execution process outlined in the figure will be documented in the PMP.

An IDEF0 context diagram is called an "ICOM". The elements of an ICOM are defined below to provide a better understanding of what Figure 11represents:

- I = Inputs for the process and is represented by the arrows on the left side of the box
- C= Controls for the process is represented by the arrow on the top of the box
- O=The outputs of the process are represented by the arrows on the right side of the box
- M=The mechanisms or resources required to perform the process and are represented by the arrows on the bottom of the box

The Figure 12 context diagram describes the execution process as having the current state or as-is military (DOTMLPF) and commercial processes as inputs to the process. The established execution controls would ensure the selected experimentation method was adhered to during the experiment. The mechanisms and resources for an SM21 experiment would normally consist of people, tools, and infrastructure required for completing the experiment. The output of the experiment is the revised DOTMLPF, commercial requirements, and knowledge for capture and dissemination.

This entire process outline in Figure 12 will be documented in an approved PMP for each experiment.

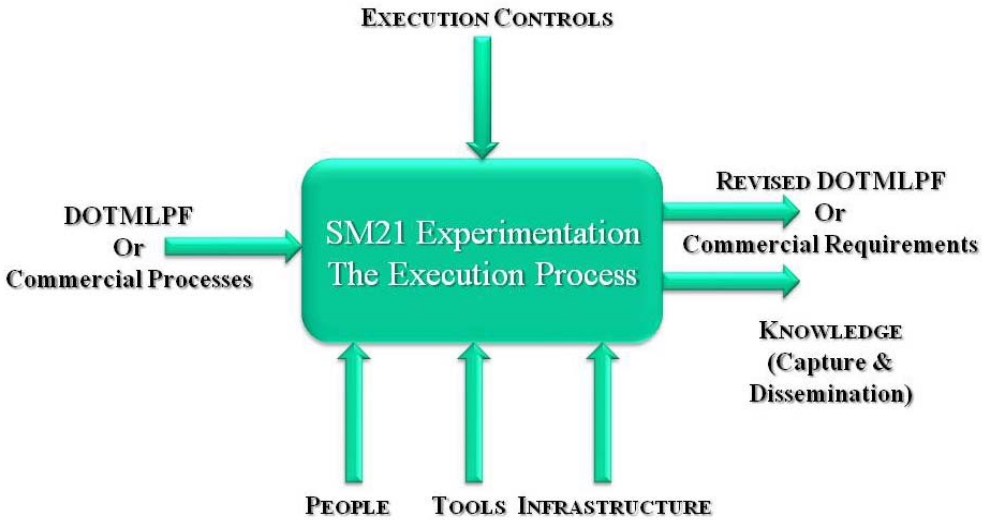

Figure 12: Experimentation Execution Process

Table 1 provides an overview of the near term experiments that were introduced in Figure 7 at the beginning of this section. The table provides an overview of the associated hypothesis, current (as-is) state, future (to-be) state, attributes, agreement status, metrics, and effects for each near term experiment planned.

Table 1: Near Term Experimentation Overview

PROJECTS:	DOLE FOODS	MARAD-CHCP Drayage Appointment System	MARAD-CHCP Terminal Dwell Time Reduction	TATRC-INTELIGISTICS Advanced Distribution Systems – 5QuadPod	USTRANSCOM Force Deployment Optimization
Hypothesis	If IM systems are provided complete and timely action level distribution data, then a new paradigm in supply chain management is created through dynamic calculation of the least cost distribution channel.	If a regional appointment system is adapted, then carbon emissions and drayage operations costs will be reduced for all stakeholders	If terminal dwell time is reduced through business process reengineering, then terminal throughput can be increased by up to 300%.	If a modular ISO Standard 1496 TEU can be built, then a modularized container system which supports level visibility will be available to: improve security; and to reduce distribution costs for both "functional" and "innovative" supply chains	If a deployment loading sequence can be created and dynamically re-planned in a collaborative environment, then deployment times will be reduced 20% and disruption to the domestic transportation network will be reduced 50%

PROJECTS:	DOLE FOODS	MARAD-CHCP Drayage Appointment System	MARAD-CHCP Terminal Dwell Time Reduction	TATRC-INTELIGISTICS Advanced Distribution Systems – 5QuadPod	PROJECTS:
As-Is	Dole "deliver" function baseline through SOCAL to Alliant, TX established during Phase I Value Stream Analysis	Two available systems (MTC and eModal) only employed by selected terminals. Excessive wait time to pickup containers on terminals.	Terminal operating at about 1/3 of total throughput capacity	Standard ISO 1492 container only	Liner, non-sequential processes
To Be	Continuous process improvement to achieve least cost deliver function	Single Regional Appointment System provided in a SOA environment	Terminal incremental throughput increases	Modular ISO 1492 Standard container	Sequential movement processes dynamically re-planned based on delivery/loading requirement.
Attributes	Least cost, integrated for total visibility, agility	Single password protected log-on for any terminal.	Continuous process improvements, agility	Flexible, secure, high capacity.	Footprint, loading rates, movement times
Agreement Status	Initial planning completed and project initiated on March 6, 2008. Pending MOA completion.	MOA Developed and Signed	MOA Developed and Signed	Pending award of SOW to Inteligistics and final MOA with TATRC	Agreement with CCDoTT to experiment with enabling IT
Metrics	Percentage of cost reduction	Carbon emission rates; wait times	Throughput rates, dwell time	Capacity, structural integrity, cost	Nodal Footprint, loading rates
Effects	Reduced product distribution costs with more agile delivery processes to match demand variations	Reduced regional carbon emissions and reduced drayage costs	More efficient terminal operations	Reduced shipment and product handling	Reduced impact on domestic transportation network and assured access to required commercial terminals

5.0 Experimentation Tools

5.1 Project Management Tools

The experimentation process described in this report will be supported by a number of management and process tools including the SM21 web based Project Management System depicted in Figure 13 below. The role-based password protected applications provide a management and communication tool for each experiment, which will have its own unique project management site.

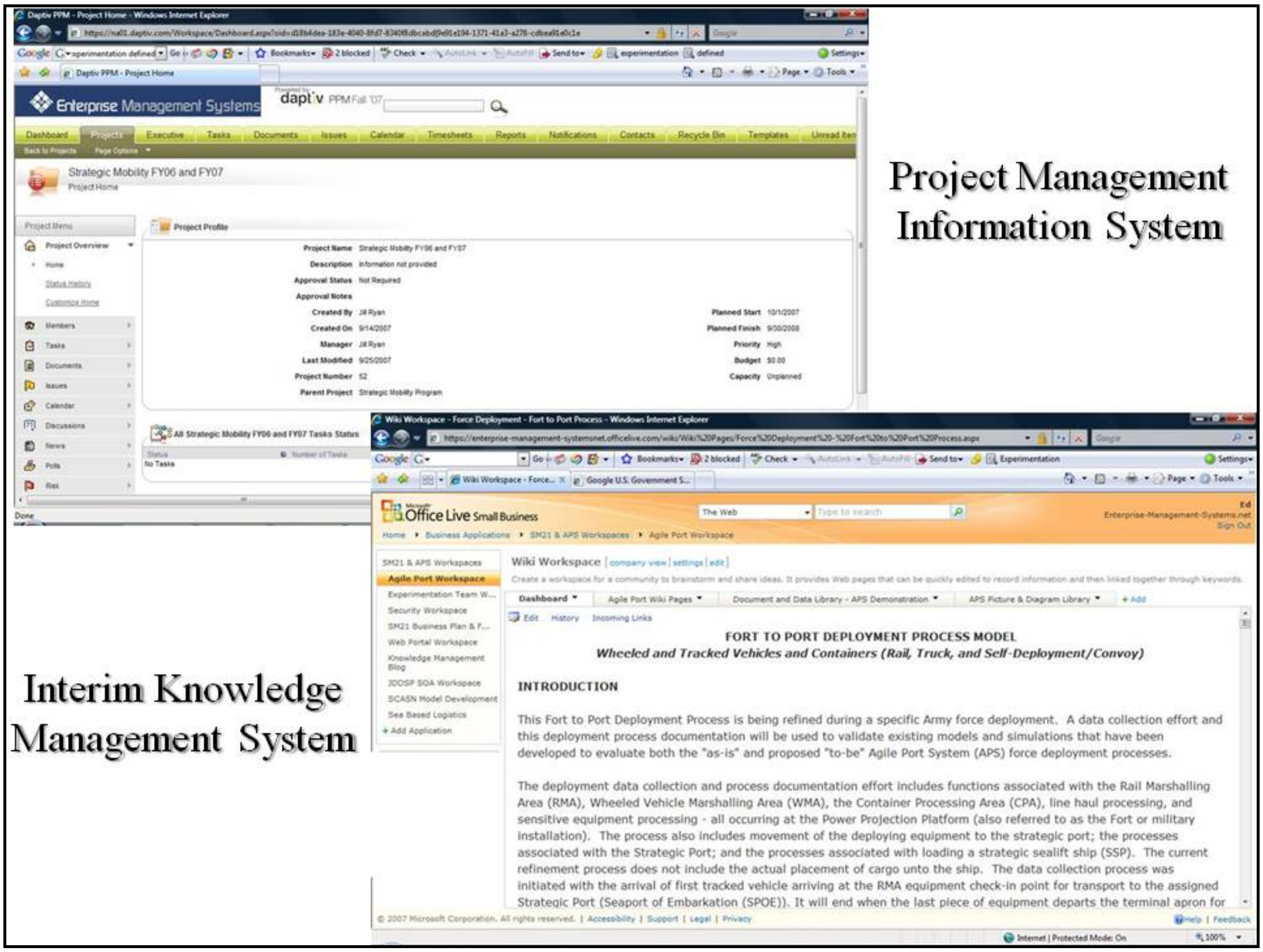

Figure 13: SM21 Project and Knowledge Management Systems

An interim knowledge management system has been employed during the initiation of the Agile Port System experimentation project. As depicted in the Figure 13, a web based, Microsoft SharePoint application was used to collaborate on the data collection effort associated with a military force deployment. A Wiki site and document and data management applications were employed by the joint CCDoTT and SM21 data collection team. The screen capture depicts the Wiki application used by the data collection team of 20 APS project personnel to document the as-is or observed deployment process.

Other tools for specific experiments, such as commercial and military supply chain analysis will use a combination of Value Stream analysis and Supply Chain Operations Reference (SCOR) Model documentation tools. For SCOR model development, the ProcessWizard™ has been evaluated for potential future use. A sample screen capture taken during the evaluation process for the Dole Foods experimentation project is provided in Figure 14. A summary of the available functions can be seen in the left menu listing. This model would be used to:

- Define process templates
- Capture knowledge and experience of key people
- Define technology solution needs from a business process point of view

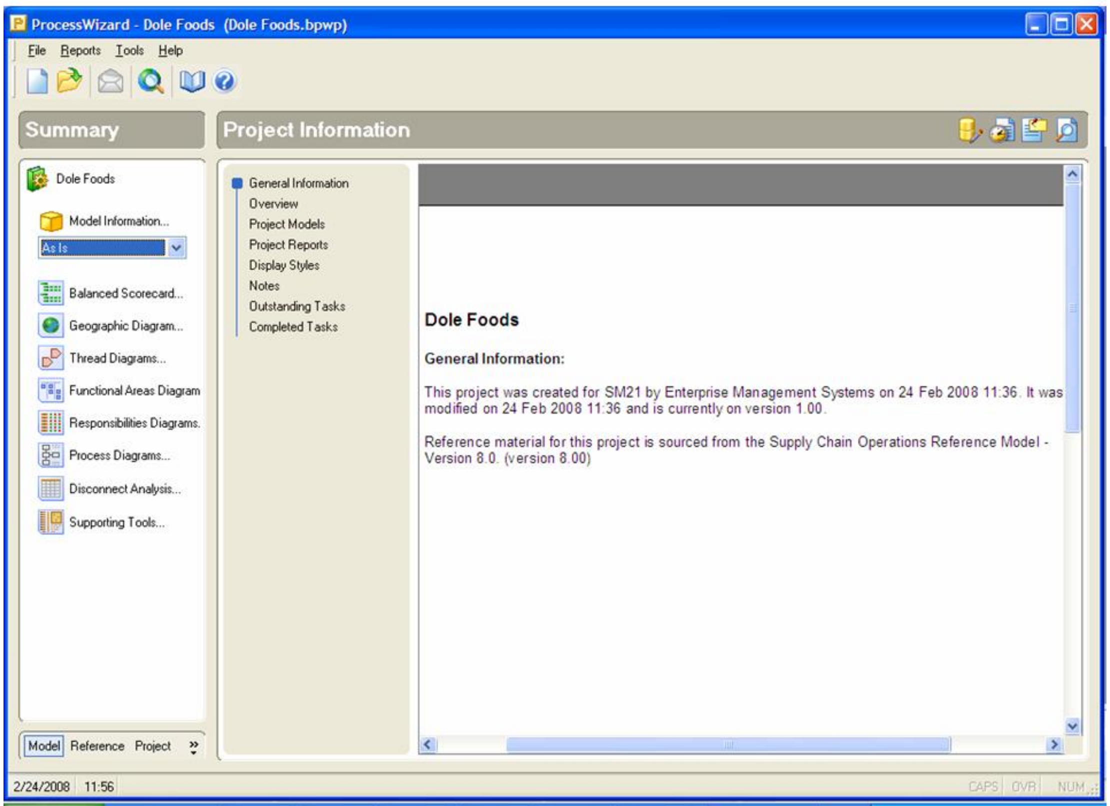

Figure 14: ProcessWizard™ Supply Chain Operations Reference Model System

5.2 Supply Chain Operations Reference Model Overview

The Supply-Chain Council, a global trade consortium with over 700 member companies including governmental, academic, and consulting groups have developed the de facto universal reference model for a Supply Chain evaluation. The "SCOR" framework has been widely adopted as a standard for business excellence. The DoD has recently adopted the newly-launched "DCOR" framework for product design as a standard to use for managing their development processes. In addition to process elements, these reference frameworks also maintain a vast database of standard process metrics as well as a large and constantly researched database of prescriptive universal best practices for process execution.

A summarized overview of Supply Chain and Distribution Logistics and the SCOR Framework for both military and commercial supply chain analysis is provided at Appendix F. Selected SM21 analysts will be trained on the use of the SCOR model and the supporting SM21 documentation tools. The supply chain includes companies and their processes for the acquisition, storage, and sale of raw material, intermediate products, and finished products. The SCOR model combines elements of business process engineering, metrics, benchmarking, and leading practices into a single framework. Under SCOR, supply chain management is defined as these integrated processes from the suppliers' supplier to the customer's customer:

- Plan
- Source
- Make
- Deliver
- Return

For the JDDSP near term experimentation, only a portion of the SCOR Deliver process will be used for evaluations. The most applicable areas include consolidate orders; ship products; manage transportation processes including import/export processes; and verify performance.

6.0 COMMERCIAL CONTAINER FREIGHT MOVEMENT OPTIMIZATION

The commercial container freight optimization experimentation currently includes one confirmed stakeholder and two stakeholders identified as potential future participants when funding becomes available. In the near term, Dole Foods has agreed to support the design, development, and deployment of the initial operating capability for the SM21 JDDSP SOA. Future identified experimentation partners include:

- Newell-Rubbermaid focusing on SCLA trans-loading operations
- Herbalife – focused on modal diversion planning

A key feature of this experimentation series will be the integration of Value Stream analysis and the Supply Chain Reference (SCOR) model to better assist Dole Foods and other participating supply chain partners in making critical "deliver" network decisions. The integration will also support cost avoidance through the availability of better planning data.

6.1 Overview of the Dole Foods Experimentation Planning

During Phase I of the SM 21 program, the Dole Foods non-refrigerated goods "As Is" value chain analysis was completed. In this second collaborative experimentation phase, SM 21 will apply the value chain and SCOR reference models to the Dole distribution network to continue the analysis of the supply chain hypothesis described in Table 1. The goal is to define the requirements for an agile "To Be" network by documenting Dole's regional distribution activities, assigning costs to those activities and analyzing Dole provided data to identify any capability gaps that exist in current processes. To close distribution visibility gaps, SM21 will evaluate the available best of breed tools to support the experimentation and the development of the JDDSP SOA IOC. The data and knowledge gained from the experimentation will be maintained in an SM21 developed knowledge management system.

The SCOR model can be applied to evaluate the degree of network integration (visibility, supply chain community, collaboration, and agility) among Dole and its distribution network partners described in this section. The Southern California Agile Supply Network (SCASN) model will also be used to support the Dole distribution network analysis.

Potential analytical considerations for the "to-be" or future state include:

- The introduction of SCLA located in Victorville, CA into the Dole domestic distribution network and
- Use of a least cost path model to determine the optimal mix of container movement via direct rail to Alliant Park TX and trans-load operations at the Buena Park, CA regional warehouse and distribution center and at SCLA.

The initial planning process for the commercial container freight optimization experimentation was completed last year after an initial exploratory Value Stream Analysis was completed on the regional distribution network for Dole Foods. The analysis was designed to determine the waste of time, effort, and any security shortcomings in the Current State, or as-is, condition of the Southern California distribution network for Dole Foods. The question that required an answer was is there a need for experimentation to optimize the select Dole Foods containerized freight shipments through the region. SM21 selected the California Manufacturing Technology Consulting (CMTC) to complete the Dole Value Stream Analysis Current State. Dole Foods was selected as the representative for large regional distribution lane shippers (e.g. Port of Los Angeles - Pier 400, land-bridge, trans-load, regional warehouse/distribution centers, and store-to-door flows). The analysis included distribution process mapping for select Dole Packaged goods' beginning from when the product arrives at the Port of Los Angeles. The analysis examined the movement of containers through the two distribution channels established by Dole Foods:

- Inland drayage of containers from the Buena Park distribution center for trans-loading prior to beginning an over the road delivery process
- Direct on-dock intermodal rail movement south via rail to the Fort Worth, Texas distribution center.

The primary objective of the completed current state Value Stream Analysis was to facilitate the identification of gaps and help prioritize future possible experimentation to improve process flows and cost control. The secondary objective was to identify the effect supply chain partners' actions had on every other firm and function touching the value stream. The Value Stream Analysis was focused on the current state with the objective of transforming and optimizing Dole's transportation supply chain starting from vessel arrival at Pier 400 (Port of Los Angeles), traveling inland by truck to the Buena Park California distribution center, and south by rail to the F.T. Worth Texas distribution center.

At the conclusion of the current state analysis Dole Foods, CMTC, and SM21 agreed that there were experimentation opportunities related to optimizing the Dole Foods transportation supply chain operations through Southern California. Of equal significance, it was determined that the Dole Foods transportation supply chain track and trace requirements could be used to design and establish the initial operating capability for the SCLA prototype JDDSP.

6.2 Research and Experimentation Objectives

There are several objectives associated with this research, development, and experimentation project that are applicable to the dual-use nature of the JDDSP. The primary objectives are listed below:

- Provide the required processing and movement data that action level systems and resources need to achieve the objectives listed below, which are dependent on timely, complete, and accurate data.
- Eliminate or minimize non-value-added container and freight processing in the regional "deliver" functions of the supply chain.
- Eliminate unnecessary transportation between sites (maximize cargo consolidated movements in "blocks" of intermodal containers)
- Create a distribution environment that supports the elimination of the production of products in excess of the amount needed to insure meeting customer needs.
- Reduce waiting for resources or other causes that delay distribution processes in the context of regional and extended distribution network – don't isolate activities.

6.3 Research Hypothesis

If action level information management systems and workers are provided complete and timely distribution data, then a new paradigm in intermodal shipping can be created by dynamically calculating and moving freight within functional supply chains using the least cost distribution channel[14]. This will provide military and civilian logisticians with more cost effective and adaptive distribution shipping methodology for functional products that have predictable demand patterns.

The process for establishing the research associated with developing the sub-problems and hypothesis for testing and experimentation is outlined in the remainder of this section. The final experimentation plan will be documented in a project management plan and will be executed through the use of the SM21 Project Management Information Management System.

6.4 Dole Foods Southern California Distribution Partners

The firms that touch the Dole Value Stream for distribution include Dole Packaged Foods Company, Maersk Lines, Maersk APM Terminals, JAC trucking company, Service Craft Logistics (a Sumitrans Corporation company), BNSF Railway Corporation, and Madison Warehouse Corporation (a Castle & Cooke Company). Each of the partners and their functions in the distribution network are described below.

6.4.1 Dole Foods

Founded in Hawaii in 1851, Dole is the world's largest producer of high quality fresh fruit, fresh vegetables and fresh-cut flowers. Dole's global reach extends to more than 90 countries, with a line of over 200 products. Dole transports large quantities of containers through the Port of Los Angeles (Pier 400) to its inland distribution center in Buena Park, California and south by rail to its distribution center in Dallas Ft. Worth, Texas.

6.4.2 Maersk APM Terminals

The Maersk APM Terminal is the main US-based unit of Denmark based container shipping company Maersk Line, which itself is a subsidiary of A.P. Moller – Maersk. Maersk, Inc. serves as an agent for its parent, handling land-based services for Maersk Line vessels from a network of about 100 offices in the US, Canada, Central America, and the Caribbean. Other Maersk Line units manage ports and terminals and provide logistics services in the region.

An important consideration for SM21 experimentation planning is the expected long term growth in world trade volumes placing challenges on port and transportation infrastructures and possibly forcing DoD to use less than optimal ports and terminals for contingency force deployment operations. Maersk APM Terminals is taking action now to invest, build and develop container terminals that will serve the future growth needs of world container trade. Equally important, Maersk APM Terminals are designing terminals to be environmentally-friendly, community sensitive, and reflecting good corporate citizenship. There are numerous opportunities for the experimentation associated with Dole Foods to support Maersk APM Terminals in their future terminal process and supporting infrastructure designs.

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[14] Fisher, M, "What is the Right Supply Chain for Your Product?", Harvard Business Review on Managing the Value Chain, Originally published in March-April 1997, pp 127-154

6.4.3 JAC Trucking

JAC Trucking is a regional trucking operator. JAC is the drayage company that picks up Dole containerized product at the port during off hours (Pier Pass) and delivers the containers to the Buena Park Distribution Center (ServiceCraft).

6.4.4 ServicesCraft Logistics

ServicesCraft Logistics is owned by Sumitrans Corporation. Headquartered in Buena Park California, it began its operations in 1958. ServiceCraft is a leading provider of third party logistics services to a wide array of industries, including consumer electronics, automotive, garments and consumer packaged products. ServiceCraft operates over 5 million square feet of premium distribution facilities located throughout the United States.

The Buena Park facility receives Dole Foods containers delivered by JAC Trucking and performs trans-loading operations to over-the-road trailers. The trans-load operations enable several delivery options, such as direct to store or direct to warehouse, based on the distribution orders received from Dole Foods.

6.4.5 BNSF Railway Company

The primary subsidiary of Burlington Northern Santa Fe Corporation, BNSF Railway Company (formerly Burlington Northern and Santa Fe Railway Company) provides freight transportation services over a network of 32,000 miles of track in the western United States and Canada. The BNSF system consists of about 24,000 company-owned route miles; trackage rights, which allow BNSF Railway to use tracks owned by other railroads, account for the remainder. Freight carried by BNSF Railway includes agricultural, consumer, and industrial products, along with coal.

The BNSF currently hauls selected Dole Foods' containerized freight in blocks directly from on-dock rail loading points to the Alliant, Texas intermodal facility for subsequent transfer to the Madison Warehouse facility.

6.4.6 Madison Warehouse Corporation

The Madison Warehouse Corporation (a Castle & Cooke Company) provides warehousing and storage including supply-line management, stocking level coordination, product reconfiguration, pick and pack, JIT order fulfillment and courier deliver. Madison Warehouse Corporation can manage the storage and transportation requirements of many companies across many industries. The Madison Warehouse F.T. Worth Texas facility specializes in beverage containers, food & grocery products, electronics, paper – bulk & processed, home & garden, specialty chemicals, industrial parts & supplies, consumer goods, and health & beauty aids. The F.T. Worth facility has 970,000 square feet with 28' by 32' ceilings. There are 118 Truck Doors (9' by 10'), Rail Service that consists of 8 doors (12' by 13'), Primary Containment, Real Time RF Warehouse Management System, Cross Dock – LTL Consolidation, and 50° Degree Cooler Storage.

The Madison Warehouse Corporation service capabilities include pick and pack, contract packaging, sub-assembly, repackaging, deliveries/courier express, reverse logistics, fulfillment, retail display configuration, EDI/RF/Bar Code Technology, and Specialized Handling Equipment.

6.5 Value Stream Analysis – Methodology

Unlike many traditional studies based on questionnaires, follow up phone calls, and attribute data (i.e., pass/fail, “how much did you save?”, etc.) gathered from select participating companies, The Value Stream Analysis methodology helps to remove “subjective” analysis from the process by quantifying the information and material flow variable (continuous) data at each sequence throughout the supply chain. Even though this requires more knowledge by users, takes longer to gather the data, and the analysis may be more complicated; the advantages include more available information, statistical techniques that can predict trends, and information is provided on the process, rather than just results.

The Value Stream Analysis methodology applied to this effort was a derivation of Value Stream Mapping as pioneered by Womack & Jones of the Lean Enterprise Institute (LEI)[15]. There are over five organizations connected to the Dole Value Stream Analysis Current State, emphasizing both agility (flexibility) and waste reduction. The analysis process selected was designed to eliminate fixing parts of the value stream for each activity without considering the impact on the entire value flow, which often occurs because of capacity constraints, inventories, sales activities, and detours ahead of the next downstream step in the supply chain. The goal was to eliminate changes that result in negligible net cost savings reaching the bottom line, lack of service and quality improvements for customers, lack of systemic long term employee “buy in” into the process, lack of supplier benefits, and limited sustainability as the wasteful norms of the whole value stream close in around the islands of pure value, and frustration all around.

The current state Dole Foods Value Stream Analysis identified the flow of information and material between the “up and down stream” Dole customers. It identified the waste and value in current processes and enabled Dole employees to think in terms of:

- Processes, Not Products or Functions
- Mapping Flow of Materials and Information between the Dole “up and down stream” internal and external customers
- Value Creation & Not Price
- Maximizing Supply Chain Relationships & Security
- Waste Removal Through Continuous Improvement
- Assigning Costs to Activities (not resources)

Given the supply chain cost drivers, Value Stream Analysis provided a proven waste reduction strategy which included measuring Current State unit input per unit of output for all resources including energy. The Value Stream Analysis Future State then designed Kaizens (process optimizations) for an improved Future State to help drive waste out of the Dole supply chain.

[15] Value Stream Mapping principles described in this report are excerpted from “Learning To See” written by James Womack & Dan Jones of the Lean Enterprise Institute (LEI).

6.5.1 Distinguishing Between Value and Waste

To help distinguish between value and waste, you need to look from the position of the consumer and ask if you would pay less for the product or be less satisfied with it if a given step and its necessary time were left out. For example would a consumer be less satisfied with pineapple juice if these current necessary activities (see Value Chain Analysis Current State Map) could somehow be left out? The answer is certain to be - no. Further, would the consumer be happier if a supermarket could get their favorite juice sooner because these steps were left out? The answer is certain to be – yes. The more these steps cause a delay in receiving exactly the product the consumer wants, the less the consumer is probably willing to pay for it. Therefore, added shipping, trans-loading, palletizing, packing, inspecting, rail yard waiting, and warehousing actions actually destroy value.

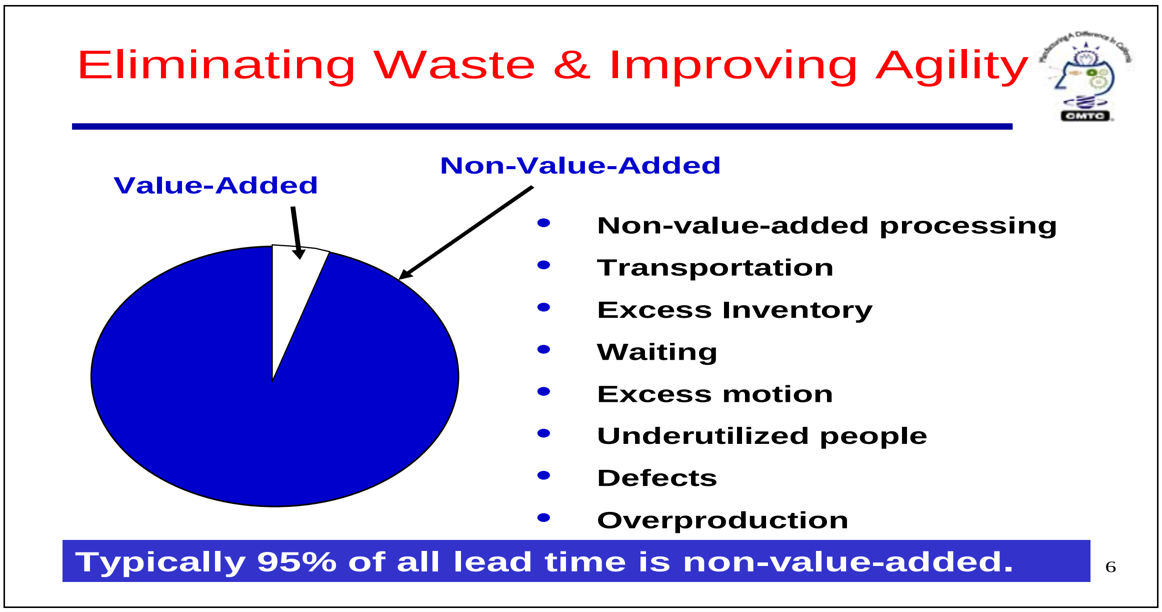

Figure 15: Eight Deadly Wastes

The waste and value stream principles used in this report are excerpted from "Seeing the Whole" forwarded by John Shook of the Lean Enterprise Institute[16].

The "8 deadly wastes" identified above in Figure 15 and expanded upon below were enumerated by Taiichi Ohno at Toyota over a half century ago. These wastes are the same at the process, the facility, and the extended value stream levels of analysis.

- **Non-value-added processing –** Activities not adding value that could be eliminated, such as a separate inspection step replaced by self-monitoring.

- **Transportation –** Unnecessary transportation between sites is the act of moving products between locations that could easily be consolidated.

[16] Eight deadly waste and value stream principles are excerpted from "Seeing the Whole" forwarded by John Shook of the Lean Enterprise Institute.

- **Excess Inventory –** Products in excess of the amount needed to insure meeting customer needs.

- **Waiting –** Usually Crane operators, Foremen, Hatch bosses, Hatch men, Swing men, UTR drivers, Draymen, Tractor fork lift drivers, Fork lift drivers, Warehouse supervisors, Rail operators waiting for machines or equipment to cycle.

- **Excess Motion –** Associates moving out of their work space to find work instructions, materials, tools, and assistance.

- **Underutilized People –** The resource management "pacemaker(s)" does not effectively match the unit of input demand to the unit of output supply throughout both the "door to door" and extended value stream. This is symptomatic of capacity constraints and excess labor.

- **Defects –** Errors in delivery performance, in products, or in paperwork supporting products.

- **Overproduction –** Making items upstream before anyone wants or needs them downstream. *A logistics example might include purchasing equipment to unload ships more quickly, even though downstream the product will sit in the rail yard for two weeks prior to transfer due to rail capacity constraints. The net result in this example is that product does not get to the consumer more quickly.*

Taiichi Ohno emphasized overproduction as the worst waste. Overproduction is frequently due to poor information flows and the desire of managers to move products ahead to meet performance metrics for equipment utilization. The Value Chain Analysis facilitates the effort for also carefully looking at unnecessary processing, defects, waiting, and motion.

When analyzing the information and material flows of the extended value stream, erratic information flows between organizations and facilities become a primary cause of overproduction. Erratic information flows, inappropriate upstream batch processing, and non-collaborative location based decisions seeking to optimize performance at individual locations along the value stream (rather than entire value stream) combine to form excess inventories and unnecessary transportation.

6.5.2 The Characteristics of an Agile and Lean Value Stream

The basic characteristic is the awareness by everyone in the entire value stream of the rate of customer consumption of the product at the end of the stream. Second, the minimum amount of raw materials, work in process, and finished goods inventories should be required in support of the next downstream customer given:

- The variability of downstream demand,
- The capability of upstream processes, and

- The inventory required between processing steps due to batch sizes and shipping quantities.

Third, an agile and lean value stream would minimize the number of transport links between steps from production to consumer. Fourth, the system would minimize as much information processing as possible replacing it with pure signal and no noise in the remaining information flows. Fifth, the shortest possible lead time should be established for processing. Sixth, changes to reduce lead time, transport, inventories, and improve flow should involve minimum cost.

6.6 The Dole Value Stream Analysis – Current State

The Value Stream Map provided below is intended to visually depict the breadth and depth of the Dole Foods transportation supply chain analysis. The contents of this map are described in the following sections with higher resolution maps provided.

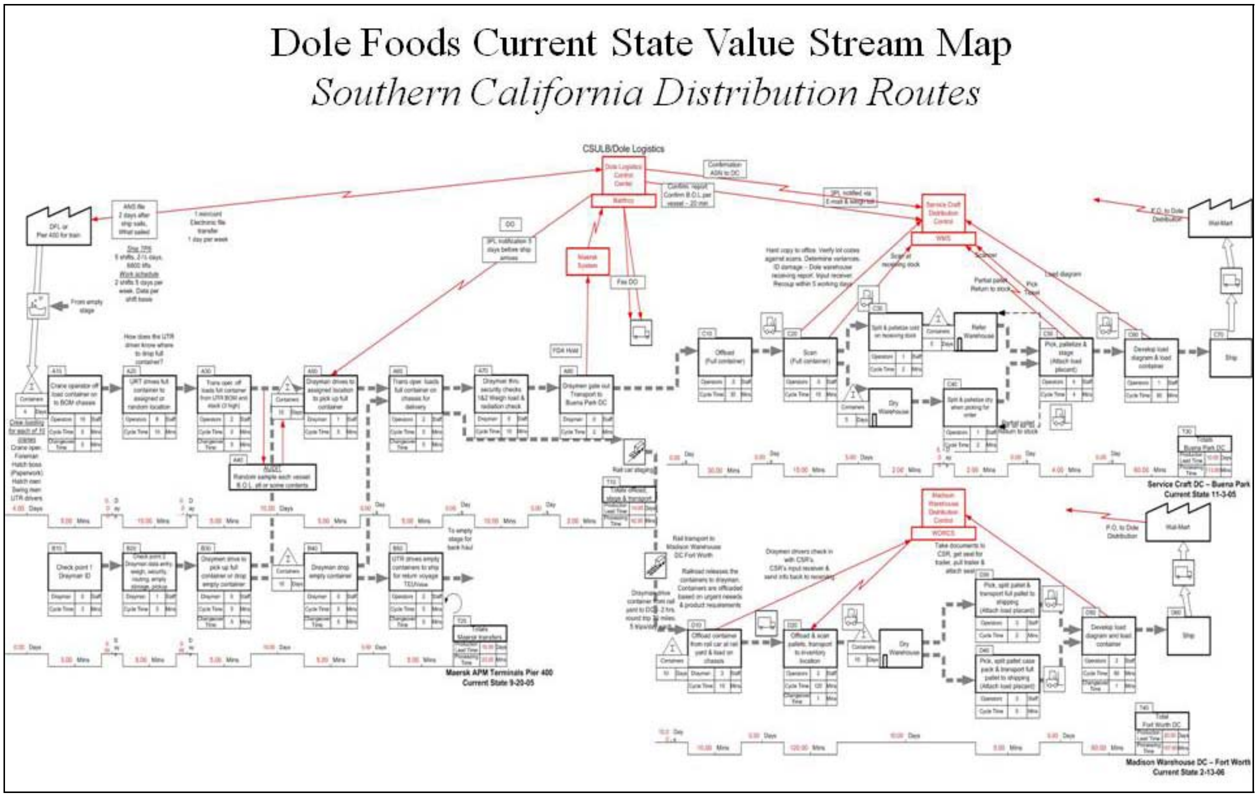

Figure 16: Dole Foods Current State Value Stream Map

6.6.1 The Current State Dole Foods Transportation Supply Chain

The analysis described below was used to identify the experimentation opportunities for Dole Foods and SM21. The processes have also been used to establish the nodes-arcs and associated facility attributes to enable business process modeling by the Southern California Agile Supply Network (SCASN) model. The SCASN will be used to model and simulate the To-Be state for the Dole Foods Value Stream prior to actual experimentation with the Dole Foods supply chain.

The Dole Value Stream Current State begins with the vessel arriving at Maersk APM Terminal - Pier 400, Port of Los Angeles. Maersk APM Terminal 400 has 10 cranes operating for two shifts per day, five days per week for a total of 20 shifts per week. There is one crew per crane. Each crew consists of a Foreman (lead), Hatch bosses (manage paperwork), Hatch Men (watch to see that the latches are connected correctly in the right order), Swing men (put the locking cones onto the containers so that the containers can stack properly), UTR drivers (have 7 or 8 drivers assigned to each crane), and the Crane operator (works 4 hours On and 4 hours Off).

6.6.1.1 Local Drayage Operations – Port to Trans-load Point

The vessel is berthed at terminal 10 and the cranes align themselves to unload the vessel. The crew of each crane un-loads containers from the appropriate ship cell and places them onto individual chassis. The containers are then stacked at the designated slot storage spaces based on the computer system generated slot. Three days before the vessel is discharged, Dole's 3rd party logistics firm (3PL) is informed of the container(s) arrival. At this point JAC Trucking is notified and the individual drayman is subsequently notified to take the pickup order to the terminal. The drayman checks in at the terminal by stopping at security check point #1 to provide ID for access. The drayman then drives to clearance check point #2 where they enter their 4 digit ID number during which point the truck is weighed; security clearance takes place, and a Routing (Load In, Load Out, Empty In, Empty Out). The drayman is also provided the appropriate storage spaces to either deliver an empty and/or drive to the target storage space for pick up of the designated Dole Foods container. At this point the drayman drives the empty container they have brought to the terminal to the appropriate storage space where the empty is removed by the lift operator and the container is stacked appropriately. Next the drayman drives to the target storage space where his/her container is located for pick up, and placed onto his chassis by the lift operator. On occasion the drayman may be required to pick up a chassis if they have not delivered an empty container. The drayman then drives through the exit radiation portal (Checks the radiation levels with Customs observation). From here the drayman "outgates" (checks out of the port through security check point #1 were the load is weighed).

The drayman drives to the ServicesCraft (3PL) warehouse at Buena Park where they validate the proper seal and validate which container the drayman is delivering. The drayman then backs the container to the assigned door of the warehouse. At this point, the drayman picks up an empty container at the 3PL and brings it back to the port ("drop & pull").

The 3PL warehouse offloads the container (3PL has the packing list and shipping manifest). All products are on slip sheets (not on pallets) as the 3PL pulls from the slip sheets and place them onto "in house pallets". Inspection occurs followed by taking a slot location in the warehouse for storage (product is scanned in with RF slot put away location enabling the 3PL warehouse to locate specific product orders). From there, the 3PL ships from the warehouse to the customer.

6.6.1.2 Sequence of Events for Rail Operations and Local Drayage

The FT Worth, Texas Madison Warehouse has a similar sequence of events with the primary distinction being that containers arrive via BNSF Rail from Pier 400 Port of Los Angeles to the Dallas Alliance rail yard. Draymen drive to the Dallas Alliance rail yard (5 round trips per day) and deliver to the FT Worth Madison Warehouse Distribution Center. Summarily, Dole product offloaded from vessels at Port of Los Angeles are put onto a train for Dallas where they are unloaded onto chassis picked up by truck via draymen pulling from the BNSF Alliance rail yard and delivering to the Madison Warehouse distribution center.

The sequence of events, resources, cycle time, and total lead time that occurs within the Dole Value Stream Current State for local drayage to ServicesCraft and for intermodal rail operations is outlined and analyzed below:

- Vessel arrives at port – with 4 day notification lead time prior to offload of Dole container(s)

- Crane operator off loads container onto BOM chassis – 5 minute cycle time, 5 minute change-over time, and a staff of 10 operators

- UTR drives full container to assigned or random location – 10 minute cycle time with a staff of 8 operators

- Trans operator offloads full UTR BOM and stacks (3 high) – 5 minute cycle time, 5 minute change-over time, and a staff of 2 operators

- Drayman arrives at port through Check point 1 for Drayman ID – 3 minute cycle time with 1 drayman staff

- Drayman drives to check point 2, drayman data entry, weigh, security, routing, empty storage, pick up – 5 minute cycle time with 1 drayman staff

- Drayman drives to pick up full container or drop off empty container – 5 minute cycle time, 5 minute change-over time, and staff of 1 drayman

- If product is randomly selected for audit (sampling of each vessel - BOL all or some contents) then – 10 day lead time prior to next step

- Drayman drives to drop off empty container – 5 minute cycle time, 5 minute change-over time, and a staff of 1 drayman OR if drayman arrived at port with empty then drayman drives to assigned location to pick up full container – 5 minute cycle time with 1 drayman staff

- Drayman drives to Trans Operation where Trans Operation loads full container onto chassis for delivery - 5 minute cycle time, 5 minute change-over time, and staff of two

- UTR drives empty containers to vessel for return voyage TEU value – 5 minute cycle time, 5 minute change-over time, and a staff of 2 operators.

    - Note that total processing time for product from time of draymen check in at check point through UTR driving empty containers to vessel for return voyage is 23 minutes. If product is selected for random audit, then total lead time is 10 days.

- Drayman drives through security checks 1 and 2 to weigh the load and security exit clearance followed by radiation portal to check for radiation levels – 10 minute cycle time with staff of 1 drayman

- Drayman gates out Transport to Buena Park Distribution Center – 2 minute cycle time with staff of 1 drayman OR product container gets put onto BNSF rail car staging area for delivery to the BNSF Dallas Alliance rail yard

- Drayman arrives with container at Buena Park Distribution Center location and checks in with the 3PL warehouse for validation of the proper seal, correct container for delivery, and backs the container to the door of the warehouse

- Drayman offloads, picks up an empty container at the 3PL and brings it back to the port ("drop & pull")

- 3PL warehouse offloads full container – 30 minute cycle time with 0.5 operator staff

- 3PL inspect – scan (full container) – 15 minute cycle time with 0.5 operator staff

- 3PL split and palletize cold product on the receiving dock – 2 minute cycle time with 1 operator staff OR 3PL take product straight into Dry Warehouse inventory – 5 days lead time

- From the split & palletizing of cold product at the receiving dock the product goes into Refrigerated Warehouse inventory – 5 day lead time

- From dry warehouse product is split & palletized dry when picking for order – 2 minute cycle time with 1 operator staff

- Pick, palletize & stage (attach load placard) – 4 minute cycle time with staff of 4 operators

- Develop load diagram and load container – 60 minute cycle time with staff of 1 operator

- Ship to customer

  Total production lead time for Buena Park is 10 days. Total processing time for Buena Park is 113 minutes.

- Note that Container product traveling by BNSF rail to FT Worth Texas is placed in a rail car staging area at Pier 400 – 14 day production lead time and 42 minutes of processing time for total offloads, staging, and transport at Maersk APM Terminal

- Rail transport to BNSF Alliance Rail yard in Dallas – 10 day lead time of days of on hand inventory sitting in Alliance rail yard.

- Drayman arrives at rail yard, drive container from rail yard to FT Worth distribution center which is 2 hours round trip/70 miles completed 5 times per day. Rail yard releases container to drayman, and containers are offloaded based on urgent needs of product requirements. Offload container from rail car at rail yard and load onto chassis – 10 minute cycle time with staff of 3 draymen.

- Drayman arrives at FT Worth Madison Warehouse Distribution Center to offload and scan pallets, transport to inventory location – 120 minute cycle time, 1 minute changeover over, and a staff of 3 operators

- Product moves to dry warehouse inventory – 10 day lead time

- Pick, split pallets, and transport full pallets to shipping (attach load placard) – 2 minute cycle time with staff of 3 operators OR Pick, split pallet case, pack, and transport full pallet to shipping (attach load placard) – 5 minute cycle time with staff of 3 operators.
- Develop load diagram and load container – 60 minute cycle time, 1 minute change-over time, and a staff of 3 operators
- Ship to customer

Total production lead time for FT Worth is 20 days. Total processing time for FT Worth is 197 minutes.

6.7 Identification of the Future State

The process of identifying the current state of the transportation-distribution aspects of a commercial or military supply chain is to establish the areas for improvement and possible experimentation. Therefore, the primary objective of the Dole Value Stream Analysis was to facilitate the identification and help prioritize future implementation of improved process flows, cost control, and agility through the Value Stream Analysis transformation. Opportunities for experimentation were also identified. The Dole Value Stream Analysis transformation is focused on Dole Packaged Foods' pre-selected target product family moving through the transportation supply chain starting at the Port of Los Angeles (Pier 400), traveling inland by truck to the Buena Park Distribution Center, and south from Pier 400 by rail to the FT Worth Madison Warehouse Distribution Center.

In review of the Dole Value Stream Analysis Current State, the Total Production Lead Time was compared to Total Processing Time. In comparing these, the viewpoint of the consumer is taken to determine if a customer would pay less for a product or be less satisfied with it if a given step and its necessary time were left out. To help distinguish between value and waste, we identified Total Production Lead Time as Non-Value Added (NVA) and Total Processing Time as Value Added (VA). This significance being that "low hanging fruit" opportunity for improvement is typically more easily identified in the difference Non Value Added (NVA) minus Value Added (VA).

TOTAL MAERSK APM TERMINAL TRANSFERS	
Production Lead Time (NVA)	10 Days
Processing Time (VA)	23 minutes

Total processing time for product from time of draymen check in at check point through UTR driving empty containers to vessel for return voyage is 23 minutes. If product is selected for random audit, then total lead time is 10 days.

TOTAL OFFLOAD STAGE & TRANSPORATION APM TERMINAL & RAIL CAR STAGING AREA	
Production Lead Time (NVA)	14 Days
Processing Time (VA)	42 minutes

Container product traveling by BNSF rail to FT Worth Texas is placed in a rail car staging area at Pier 400 – 14 day production lead time and 42 minutes of processing time for total offloads, staging, and transport at Maersk APM Terminal

TOTAL MAERSK APM TERMINAL TRANSFERS	
Production Lead Time (NVA)	20 Days
Processing Time (VA)	197 minutes

Total production lead time for FT Worth is 20 days. Total processing time for FT Worth is 197 minutes.

6.7.1 Recommended Improvements and Experimentation Opportunities

Initial recommended Kaizens (improvement opportunities) for waste reduction, constraint elimination, and improved agility are identified as follows. These will be prioritized by Dole and SM21 in collaboration with Maersk APM Terminal, JAC Trucking, Service Craft Logistics, BNSF, and Madison Warehouse, Inc.

- Kaizen 1 (Figure 17): Full upload electronically of the Dole ANS files
- Kaizen 2 (Figure 18): Confirm Dole report/confirm Bill of Lading per vessel
- Kaizen 3 (Figure 18): Dole 3PL notified via weigh bill
- Kaizen 4 (Figure 17): Load container on to trailer chassis ready for delivery
- Kaizen 5 (Figure 17): Fixed staging locations for specific customers (Dole/Maersk)

Other identified opportunities:

- Containers sit for 10 days at BNSF Dallas Texas Alliance Rail Yard rail car staging area prior to having those containers offloaded from the rail car and loaded onto chassis for delivery by truck to the FT Worth Madison Warehouse.
- Dwell time reduction at Maersk APM Terminal/Pier 400
- Cycle time reduction at Maersk APM Terminal/Pier 400
- Appointment system (Draymen scheduling) for gate queue at Maersk AMP Terminal/Pier 400

6.7.2 Development of the Experimentation Project Plan

The recommendations listed above will be reviewed as the first step in the development of the Dole Foods experimentation project management plan. This initial experimentation plan will also support the deployment of the JDDSP initial operating capability.

6.8 Conclusions: Container Freight Movement Optimization Experimentation

The process followed to identify the As-Is or current state of a distribution network outlined above will be used as a start point for developing a solid knowledge base for maintaining or refining the processes employed.

The future state implementation of To-Be improvement projects as prioritized through the Dole Foods Value Stream Analysis places heavy emphasis on intermodal rail operations, its bottlenecks, and associated expenses up and down the supply chain. Since there is a 1:1 correlation between Lead Time reduction and Days of On-Hand Inventory, we can very quickly see that a 10 day bottleneck can translate into a huge expense of tied up working capital costs. In addition, if a business is able to get their products through the system to the customer more quickly, then it can establish a competitive advantage.

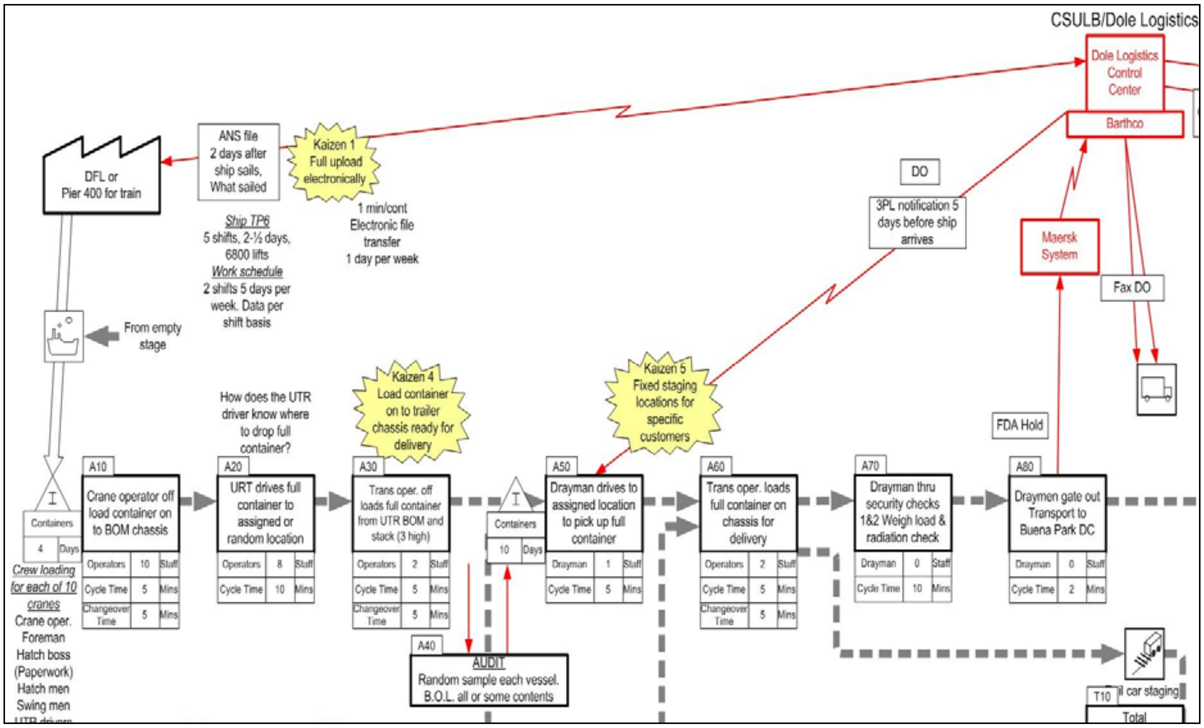

Figure 17: Dole Foods Value Stream Map – Kaizen's 1, 4, 5

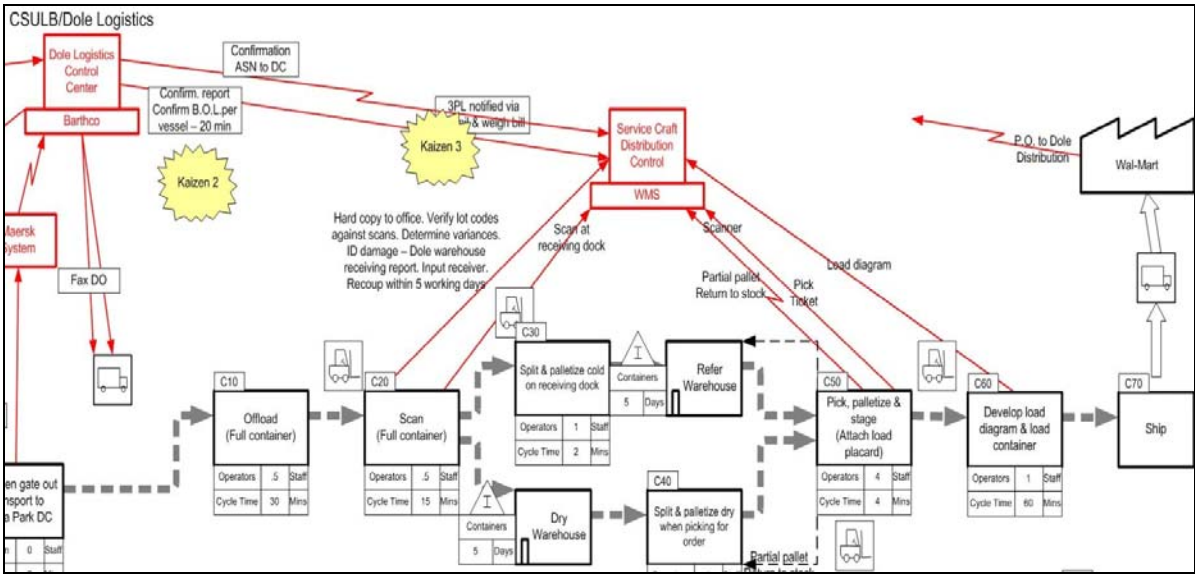

Figure 18: Dole Foods Value Stream Map – Kaizen's 2 and 3

The courses of action to be followed in developing the experimentation project plan for Dole Foods:

- Begin further analysis by drilling further down vertically into the existing Dole transportation supply chain to get to the level of the import manager and quantify what is truly value added.
- Expand the horizontal research into the individual supply chains to begin to show the impact of aggregation. This consists of quantifying the primary bottlenecks including the intermodal rail, the reduction of dwell times, cycle times, and improvement via an appointment system for the facilitation of draymen scheduling at the gate queue. It is important to note intermodal rail as particularly relevant and the impact of the Victorville tie in trade lanes in helping to reduce dwell times and cycle times downstream from the port.
- Jointly between Dole Foods and SM21 establish the experimentation plan based on the selected improvements listed in paragraph 4.5.1 above.

7.0 CONTAINER APPOINTMENT SYSTEM AND DWELL TIME REDUCTION

7.1 Background

A Memorandum of Agreement (MOA) was established between the Maritime Administration (MARAD) and Strategic Mobility 21 (SM21) to define the guidelines and responsibilities for jointly managing projects involved with dwell time reduction and appointment system implementation at marine terminals. MARAD would have the Cargo Handling Cooperative Program (CHCP) establish and manage their portion of the project. MARAD developed the CHCP with the goal of increasing the productivity of marine freight transportation companies through cargo handling research and development. The CHCP, conceived as a public-private partnership, works to foster research and technology development among U.S. intermodal companies. The members actively pursue innovative cargo handling development to increase productivity and cost effectiveness of cargo operations. Although the initial agreements have been made, yet to be determined are the project execution details and the development of the joint project management plan.

The Terminal Dwell Time Reduction and Marine Terminal Appointment System research, development, and experimentation project will, along with the Dole Foods project, support the development of the JDDSP initial operating system and management services. The programs will be closely coordinated to leverage joint experimentation opportunities and continuous process improvement opportunities.

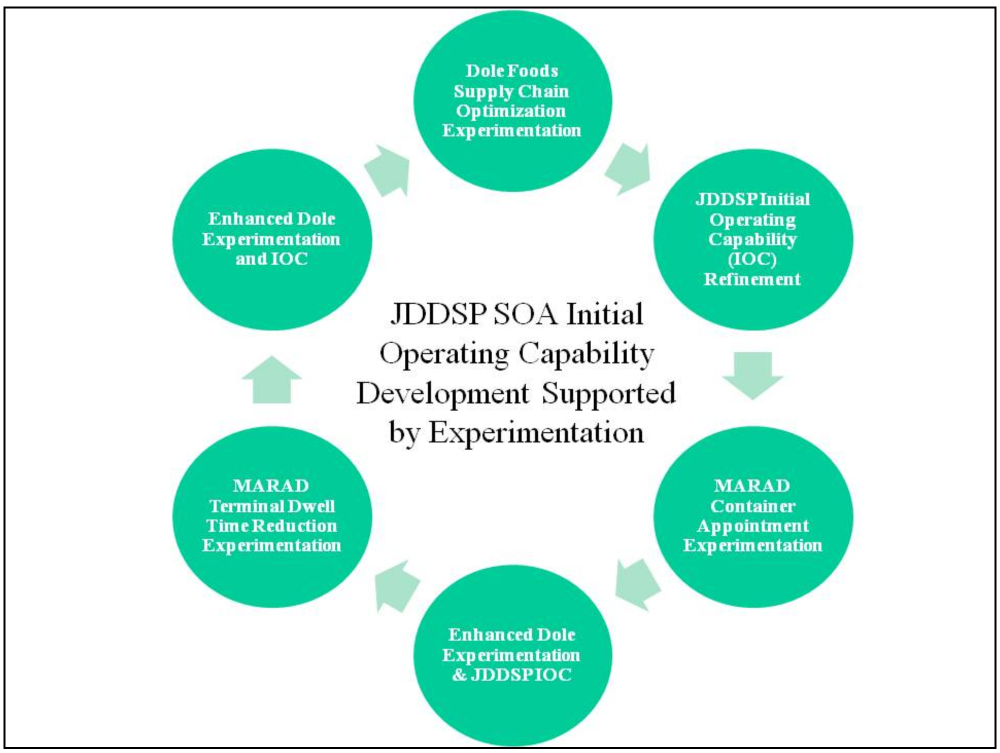

Figure 19: Development of JDDSP IOC Supported by Experimentation

7.2 Identification of the Problem

Over the past twenty years the manufacturing and distribution patterns in the United States have been dramatically altered. As the world's largest consumer nation, the impact of overseas manufacturing created an environment where the U.S. receives a significant portion of its imports by water. These imports are mainly by container and this traffic has a significant impact on regional transportation networks supporting ocean terminals. Recent events have shown that this distribution network is vulnerable to a variety of challenges including, work slowdowns, port congestion, economic disruptions, natural disasters, and the threat of terrorist actions. All of these issues can have a negative effect on the national economy and the public's well-being. Forward thinking businesses are now attempting to make maximum use of existing terminal space by partnering to find ways to keep the economy growing while insuring that the environment and public quality of life issues are not negatively impacted.

The value of research and experimentation associated with reducing container dwell time and establishing a marine terminal appointment system was supported by the Dole Foods Value Stream analysis. As outlined in Section 5, the primary objective of the Dole Foods Value Stream Analysis was to facilitate the identification of gaps and help prioritize future possible experimentation to improve process flows and cost control. The secondary objective was to identify the effect supply chain partners' actions had on every other firm and function touching the value stream. The Value Stream Analysis focused on the current state with the objective of transforming and optimizing Dole's transportation supply chain starting from vessel arrival at Pier 400 (Port of Los Angeles), traveling inland by truck to the Buena Park California distribution center. The analysis clearly identified a need to reduce marine terminal container dwell time and the usefulness of a terminal appointment system. The following items directly related to dwell time reduction and the appointment systems were identified as requirements for further research and experimentation:

- Fixed staging locations for specific customers (Dole/Maersk)
- Dwell time reduction at Maersk APM Terminal/Pier 400
- Cycle time reduction at Maersk APM Terminal/Pier 400
- Appointment system (Draymen scheduling) for gate queue at Maersk AMP Terminal/Pier 400

As part of seeking possible solutions, the Cargo Handling Cooperative Program (CHCP) met with the West Coast Marine Terminal Operator Agreement (WCMTOA) members to discuss the challenges caused by increased throughput at U.S. marine terminals. The initial meeting participants included selected terminals, carriers, and POLA/POLB. There were no customers in the initial meeting. The meeting was a constructive dialogue about several issue areas that would be most beneficial to increasing throughput throughout the industry. The result of the meeting was for the CHCP to undertake the investigation and evaluation of dwell time and appointment systems at marine terminals.

The following are the relevant issues discussed at the CHCP-WCMTOA meeting:

- Terminal throughput must be approximately tripled by 2020.

- Productivity per terminal acre-per year must be increased from 4,200 containers to 10,810
- Project should be to evaluate appointment systems and the reduction of dwell time
- Identify as-is or current situation, then address program to double throughput followed by projects to triple throughput.
- PierPass was initially selected to run the scheduling program but it was decided that they would require too many additional agreements to add this program.
- Existing appointment systems: MTC Voyager and eModal.
- Discuss dwell vs. free time – how to approach
- Zero demurrage cost to shipper
- Systems development objectives include lowest cost, simple functionality, scalability, and business process development. Application development must be a collaborative effort.
- System benefits to terminal – reduced free time and others that should be identified during the initial project discovery process
- Project should address pros and cons of adoption
- Should allocate a cost per container for the operating system

7.3 Research and Experimentation Objectives

There are several general objectives associated with this research, development, and experimentation project that are applicable to the dual-use nature of the JDDSP. The primary objectives are listed below:

- Provide the required processing and movement data that action level systems and resources need to achieve the additional objectives listed below. All of the objects are largely dependent on timely, complete, and accurate data.
- Eliminate all possible non-value-added processes in a marine terminal.
- Eliminate unnecessary time delays in container drayage operations at marine terminals
- Determine if a marine terminal appointment system can reduce drayage operator wait times for container pickup.
- Reduce waiting for resources or information that delays distribution processes in the context of the regional and extended distribution network – don't isolate activities.

7.4 Hypothesis

"If marine terminals are able to prepare and schedule containers for movement off-terminal upon their discharge, then terminal throughput would be increased by up to 300%."

The processes for establishing the research to identify the sub-problems and hypothesis for testing and experimentation are outlined in the remainder of this section. One sub-problem would examine the implementation of a standard regional drayage operation appointment system. The experimentation plan will be documented in a project management plan and will be executed through the use of the SM21 Project Management Information Management System. The MOA established between the MARAD and SM21 states that the final project management plan will be jointly developed and will include guidelines and responsibilities associated with

SM21-CHCP joint projects involved with dwell time reduction and appointment system implementation at marine terminals.

7.5 Overview and Approach to Selected Terminal Throughput Enhancements

The two proposed projects, container dwell time and appointment systems, were selected based on their potential to provide the greatest productivity increase for marine terminals. The following sections describe the objectives for both the dwell time and appointment system projects, which will be executed through collaborative experimentation with impacted stakeholders.

7.6 Overview of Dwell Time Reduction Issues

The scope of the work for dwell time reduction has been agreed to by MARAD and SM21. The effort will be based on recommendations by marine terminal operators. The recommendations will be presented to SM21 and the CHCP, or to their designated contractor, who will conduct a survey of the current practice of managing dwell time at marine terminals, analyze the results and make recommendations to industry. This would be followed by an evaluation of alternatives that would outline common practice, based on agreed upon criteria and standards. This may require further consideration at the Federal level. All options will be submitted to the marine terminal operators for review, discussion and possible implementation.

To date, container dwell time at marine terminals has been a marketing tool for terminal operators to provide free storage for their customer's cargo. However, in many Asian terminals dwell time is kept to a minimum, sometimes as short as hours, to ensure that the terminals are fully utilized for moving cargo. For container terminals to be truly efficient, cargo must move off the terminal almost as soon as it touches the dock. "Free Time" was not an issue when terminals were underutilized. With the current increase in cargo, containers need to move more quickly to their ultimate destination. Today infrastructure is beginning to be stressed and the use of terminals to store or delay container movement exacerbates congestion particularly for those terminals that already have limited space for processing import and export containers. The Dole Foods Value Stream analysis also determined a critical need to reduce container processing steps and wait times between processes.

7.7 CHCP Approach to Dwell Time Reduction Issues

As an early task, the CHCP and SM 21 will review current policies and practices associated with free time and container dwell time at marine terminals. SM21 has collected initial information on dwell time in Southern California terminals and will add to this body of knowledge during the first phase of this effort. This data collection effort will be followed by an evaluation of alternatives to establish common practices based on accepted criteria and standards. Any required coordination at the Federal level will be completed by SM21. The final analysis of alternatives will be submitted to the participants for review, discussion, modification, and to establish the development and experimentation plan.

To support the analysis and evaluation of alternatives, SM21 will provide terminal and regional modeling and simulation support with a focus on statistical analysis. SM21 has the ability to provide a combination of models. The Southern California Agile Supply Network model and the Multi-modal Terminal Model will enable regional business process modeling using an Arena based simulation. An analytical, least cost path model is also available for regional distribution modeling. Models employed will be able to discern the differences (value) between old and new business policies and operational concepts.

7.8 Overview of Truck Appointment Systems

Although used on a limited basis, appointment systems show promise in reducing in-gate/out-gate congestion. Recent advances in information technology systems make it now possible to implement appointment systems on a wide scale. In the MOA between MARAD and SM21, MARAD proposes to work with SM21to demonstrate an appointment system. The objective is to use an existing organization to configure an appointment system based on defined criteria and procedures. This is similar to the approach being taken with the Dole Foods experimentation.

Appointment systems have the potential to provide significant increases in terminal efficiency. It is not uncommon today for drayage operators to arrive at a terminal unannounced to pick up or drop off a container. This practice has historically created delays caused by containers not being ready for pickup. Containers are often in inaccessible locations or not on roadworthy chassis when truckers arrive. As a result truckers can wait hours in a terminal for containers that may be located at the bottom of a container stack.

7.9 Approach to Developing Concepts, Solutions, and Experimentation Projects

7.9.1 Dwell Time and Free Time

The initial information required for this project has already been developed through the Dole Foods project and will be expanded during the future state analysis. Additional surveys of other participating members and their current free time and dwell time data will be collected and analyzed. The data collection plans related to dwell and free time must be carefully designed if the results are to be meaningful. Some implications related to dwell time are:

- Aggregate statistics will be at the terminal level; however, process event data across all internal movement arcs and nodes will be collected
- Important factors that influence dwell time will be collected to provide data on level of service and the method of onward transportation
- Procedural information will be collected to determine if they affect dwell time

Information collection about free time policy will be reviewed to determine what factors are important to common practices. Collection of the basic descriptive information concerning available resources and resource utilization practices at each terminal will be conducted to the extent that they are likely influences on dwell time and free time. The data and process information will be sufficient to employ both the SM21 description and prescriptive models.

Throughout the process, interaction with each participating terminal will be maintained using a secure, collaborative web site that will protect confidential information and proprietary data. Definitions, methodologies, models, and the alternatives they are based on, will be shared with all participants on the project collaborative web site to build consensus. Aggregate and non-attributable data and analysis results will be available for all to discuss using the experimentation tools defined in Section 4.2 of this report.

7.9.2 Appointment Systems

A recent study by METRANS will be leveraged during initial project analysis. The study has identified factors that influence appointment system effectiveness at POLA/POLB. While much of the data gathering and interview processes from the study can be used, neither the METRANS study nor any similar studies have considered factors that contribute to terminal dwell time or how advanced technology might allow more effective scheduling of operations at terminals. However, the SM21 Dole Foods Value Stream analysis does provide detailed information on process and information management system inefficiencies associated with the processing of Dole containers through a single terminal.

Potential contributions of new and advanced technologies that will be considered during this experimentation project include:

- Use of a service oriented architecture to integrate existing commercial services into a single web portal.
- Development of adaptive scheduling services to better respond to changes by rescheduling appointments.
- Development of mathematical programming services to choose appointments in each scheduling window.
- Integration of truck and/or driver tracking services to inform terminals of expected arrival times.
- Integration of additional services as required for improving the effectiveness of Terminal Operating System software to reduce container delays.
- Improved business practices.

7.10 Primary Stakeholder Responsibilities:

7.10.1 MARAD

- Act as the lead organization for this agreement,
- Manage the day-to-day activities under this agreement,
- Participate in all project activities,
- Assist in developing project cost estimates,
- Develop and maintain all work schedules for the projects,
- Assist in project funding,
- Use of member facilities for project purposes,
- Act as the liaison between project participants,
- Be responsible for collection and evaluation of data,
- Write quarterly and final project reports.

7.10.2 SM21

- Participate in all project activities,
- Assist in developing project cost estimates,

- Assist in developing project schedules,
- Participate in project funding,
- Provide access to in-house experts,
- Assist in the collection and evaluation of data,
- Assist in the writing of quarterly and final project reports.

7.10.3 MARAD/SM21

- Establishment of a Steering Group
- Establishment of a Technical Group
- Project Requirements
- Project Metrics
- Performance Measurement
- Project Scale-ability
- Transition
- Continuing roll of Participants

7.11 Information Exchange:

The MOA between SM21 and MARAD provides reciprocal rights for exchange of information between the parties regarding data, studies, analyses, and other resources and capabilities which impact or influence the projects under this agreement. The parties have agreed to share information developed under this agreement that can be shared to further their individual missions. Typical areas of information sharing range from specific topics of common and current interest to broader areas that may be developed as a result of projects undertaken by the parties. SM21 will use the experimentation tools defined in this report to enable information exchange and collaboration.

7.12 Future Follow-on Experimentation

Currently in the early stages of planning is a follow-on MARAD CHCP supported experiment that would involve the Port of Savannah. As with the Southern California experimentation, both local dray and over the road truck operators, at least one class one railroad (Norfolk Southern), a robust communications network to link and integrate stakeholders in the experiment, and a network operations center are being planned. If successful, a third experiment related to the appointment system would be the use of a JDDSP at Warner Robins/Macon area initially located at Brosnan Yards, a Norfolk Southern hump yard, with the capacity to become an intermodal facility designed to achieve a modal optimization service mix.

8.0 ADVANCED DISTRIBUTION PACKAGING EXPERIMENTATION

8.1 Introduction

The advanced packaging experimentation will examine the development of an advanced shipping container to replace or supplement the ISO Standard 1496 shipping container for both military and commercial shippers. Currently the Department of Defense (DoD) predominately uses ISO Standard 1496 containers 20' in length while the commercial sector uses the 40' version for goods movement. The SM21 will examine several alternative packaging concepts to improve the end-to-end distribution channels supporting corporate and government supply chain management processes.

Figure 20[17]: 5QuadPod™ System and ISO Standard 1496 20' Container

Near term research will center on a proposed containerized shipping system called the 5QuadPod™ depicted in Figure 20. The initial technical research question is can the 5QuadPod™ design meet the ISO Standard 1496 used to certify shipping containers? A computerized model of the 5QuadPod™ will be developed by SM21 and research partners to validate the design process, to aid with the selection of materials, including the use of new composites; and to incorporate predictive Finite Element Analysis to show how the 5QuadPod™ will react to various stress and load conditions associated with the ISO Standard. The computer model will be used to establish a virtual environment that will be a useful tool for demonstrating the versatility of the 5QuadPod™ and support the requirements discovery process with prospective users.

[17] Source of Twenty-foot equivalent picture is: http://www.konttivuokraus.fi/kontit.htm

8.2 Experimentation Stakeholders

This experimentation project is a joint effort with the concept developer, Inteligistics, and the Telemedicine and Advanced Technologies Research Center (TATRC), a section of the United States Army Medical Research and Materiel Command (USAMRMC) Headquarters. TATRC and USAMRC are interested in the development of an advanced Class VII (medical supply) distribution system, especially for Sea Based Logistics operations.

The technology partners for the project include:

- Alcoa Defense Systems Aluminum, foils, laminations
- Bayer Material Sciences plastic/metal hybrids, plastics and manufacturing processes
- Boeing Sensors and power harvesting/conservation
- Mobile Aspects RFID and Software integration

8.3 Research and Experimentation Objectives

There are several objectives associated with this research, development, and experimentation project associated with both the commercial and military sectors.

- Reduce the current tare weight of the ISO container
- Eliminate cargo load sequence by allowing the simultaneous loading of multiple pallets
- Reduce loading time
- Increase cargo density
- Accept a standard pallet dimension of 48”x40”x45”, permitting better allocation of space and distribution of cargo
- Provide capacity for 20 pallet loads
- Be able to reduce the empty footprint of the container to permit knock-down to nest five units in one
- Allow complete economical repair and recycling of worn frames and pallets
- Independent of the shipping platform, permit each pallet to function as a flat-pallet, bin, secure box or open box-frame
- Make use of compatible materials friendly to RFID/sensor technology and transparent for X-ray and scanning technologies currently in use by the U.S. Customs and Border Patrol and
- Eliminate time-consuming banding, blocking and bracing; and a myriad of other platforms currently used to prepare small shipments

8.4 Research Hypothesis

If a series of articulated frames can be designed to interlock, support and distribute the stack-weight of an equivalent ISO shipping container, then a new paradigm in modular inter-modal shipping containers can be created employing the system from the manufacture to the retail outlet shelf. This will provide the military with and civilian logisticians with a more flexible and adaptive distribution shipping platform.

8.5 Significance of this Experimentation Project

The DoD has identified a need for a more flexible, articulated and dynamic packaging and shipment system to replace the traditional the Twenty-foot Equivalent Unit (TEU) / ISO Standard 1496 shipping container for Sea Based Logistics and other distribution channels. Currently there is an acquisition study being conducted by DoD on the Joint Modular Intermodal

Container (JMIC). However, a recently completed study by LMI concluded that the JMIC may not be able to fully support Sea Based Logistics. The SM21 proposed new container paradigm for use in Sea Based Logistics and other dual-use applications will be a "System of Systems" (SOS) that utilizes an exoskeleton of frames (QuadPods™) and smart secure pallets (Quads™) to create a versatile, lightweight, and collapsible 20' ISO equivalent shipping platform called a "5QuadPod™".

The "QuadPods™" are versatile frames designed for adaptability. The concept is to use the quad units to create shipping units of 20' (5 quad units), 40' (10 quad units) or 53' (13 quad units). This would enable flexible shipping containers for configurations common to truck and rail or accommodate unitized load-out on C-17, C-130, and C5 military aircraft. Two QuadPods™ can be configured to handle a 22,000 lb rotary-lift from the deck of a ship without additional packaging or physical handling.

The true significance of this system is the flexibility in packaging that can be loaded at the manufacturing warehouse and moved in the intermodal system or across multiple modes through reconfiguration of the modular units without unloading and reloading cargo. The individual pods can also serve as display units for direct to the shelf retail operations with complete product tracking capability using the embedded RFID system.

8.6 5 QuadPod™ System Overview

A 5 QuadPod™ consists of five articulated collapsible frames and 20 lightweight modular packaging units called Quads™. Each QuadPod™ frame holds four Quads™. The Quad™ is a modular packaging system consisting of a configurable pallet base and a box-frame with sliding panels. A Quad™ measures 40"X48"X45" and weighs less than 180lb. The QuadPod™ frame weighs approximately 500lb. Total tare weight for a 5QuadPod™, including the 20 Quads™, is 6100lb. Each Quad™ can pack an expected minimum 2500lb load and the QuadPod™ frame can carry an expected minimum of 10,000lb. Minimum expected pay-load capacity for an articulated 5 QuadPod™ is 25 Net Tons or a gross weight of 56,100lb. A Quad™ can carry up to 4000 lb., but pallets would quickly exceed legal axle weight limits set by most states for 20' trailers.

Each of the articulated 5QuadPod™ frames is being designed to provide the sole load bearing element of the shipping platform. The 5QuadPod™ frame is designed to re-distribute the stack-weight of the shipping platform over 30 integral pressure points to meet the equivalent four point ISO 1496 standard established by the original ISO shipping container configuration. The structural elements of the exoskeleton will utilize leading-edge aircraft aluminum, composite and plastic/metal hybrid technology to reduce weight, while improving weight bearing capacity.

8.7 Development Efforts

Inteligistics is currently designing a Dynamic Smart Box (DSB) (Figure 24) for the Office of Naval Research (ONR). Using the experience gained from Mobile Aspects' Smart Medical Cabinets, Inteligistics sought to apply RFID, sensors, PDA/Smartphones and Internet/GPS to a Twenty-foot Equivalent Unit (TEU) / ISO shipping container. The Dynamic Smart Box is a smart transferable system that will create a virtual Warehouse-in-Motion out of a standard TEU.

This technology will be transferable to the 5QuadPod™ system and can be used for initial experimentation.

Inteligistics also provides Smart Medical Cabinets (SMC) (Figure 21) in a clinical setting (Wilford Hall Medical Center, Lackland Air Force Base). The smart medical cabinets, manufactured by Mobile Aspects, manage inventory, selectively track the use of inventoried items, relay information to accounting and re-order critical items without the active intervention of anyone beyond the technician or professional who first interacts with the system. The smart cabinet can also be set to respond to expiration dates, product alerts, manage the par level of items to be kept in reserve, create a variety of essential reports, and relocate items misplaced in the system.

Both the Smart Medical Cabinets and the Dynamic Smart Boxes will support the SM21 continuous, dual-use experimentation program and will support the development and experimentation process associated with the 5QuadPod™.

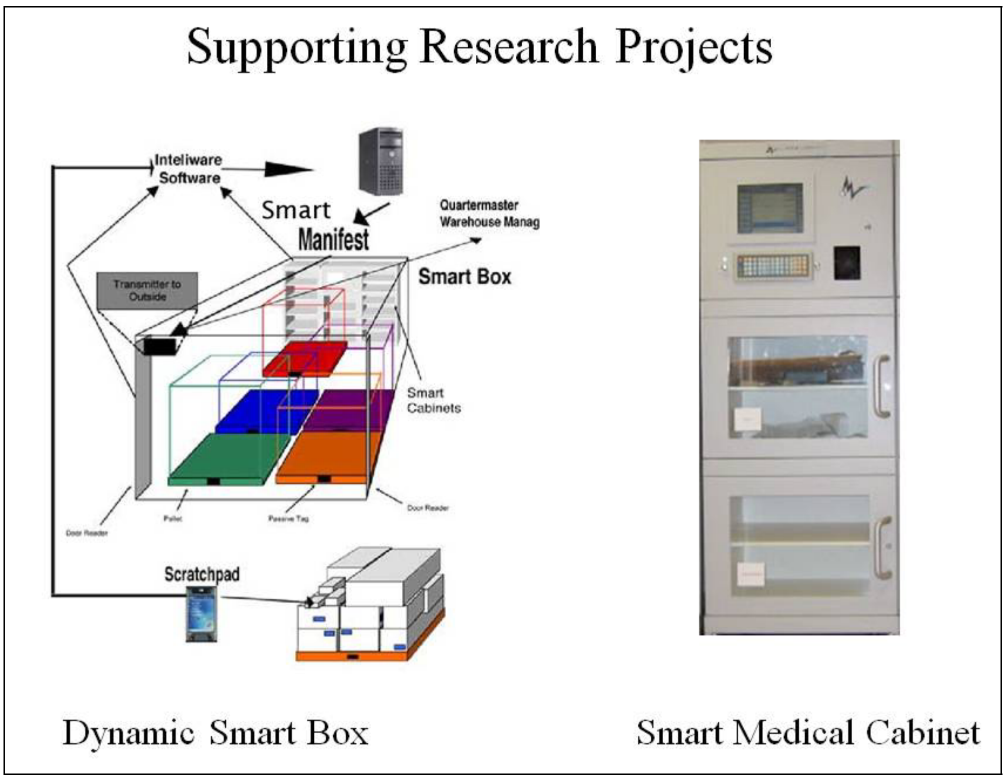

Figure 21: Supporting Research Projects

8.8 Preliminary Project Planning Overview

The 5QuadPod™ experimentation project will follow the standard SM21 experimentation planning and execution process. The project has completed initial agreements with the primary stakeholders. The next step will be a stakeholder team meeting to complete any remaining agreements and define the project management plan (PMP).

The known projects steps leading to the initial experimentation include the following major work structures:

1. Create Preliminary Specifications for the Quad™, QuadPod™, 5QuadPod™ and 5Quadcube™
   a. Structural and functional elements will be defined for each unit. A baseline design will be formulated and dimensional drawings created.
   b. ISO Standard 1496, Military Standard IAW-1660, load specifications for various aircraft and amphibious craft and national and international pallet standards will be reviewed and evaluated
   c. Cross checks will be made with the Department of Transportation, Customs and Border Patrol, and the Federal Aviation Administration to facilitate dimensional standardization as much as possible.

2. Design of a Quad™
   a. Develop the detailed designs for a unified pallet, bin, box and box frame.
   b. Evaluate materials for strength, durability, impact resistance, weight and compatibility with other structures and/or fixtures that will be embedded, laminated or attached to the materials.
   c. Material specifications will be compared with engineering specifications for the Quad and preliminary materials will be selected.

3. Design of a QuadPod™
   a. Structural design of an articulated frame with defined load characteristics and structural characteristics that govern the collapsibility of the frame, as well as, the structural elements that permit the frame to interlock, lift and secure one frame to another.
   b. Materials will be selected for weight-bearing, strength, durability, weight and compatibility with other structures and/or fixtures that will be embedded, laminated or attached to the material.
   c. Material specifications will be compared with engineering specifications for the QuadPod and preliminary materials will be selected.

4. Design Integration
   a. Design and sizing of structural elements such as hinges, attachments and interlocking mechanisms.
   b. Structural stability and integrity will be evaluated and resolved. Weight, wind-shear, seals, and other structural issues will also be addressed. Static and dynamic loads will be calculated.
   c. Conceptual development of the 5QuadPod and 5Quadcube begins; Sketches and outline drawings give way to dimensional drawings

5. Preliminary 3D Models
   a. Dimensional drawings of the Quad and QuadPod will be integrated to create a 3D Model of a 5QuadPod and 5Quadcube.
   b. Detailed design drawings are combined with detailed overlays of component drawings.

  c. Qualification of materials, final selection of materials is made and samples evaluated before the material specifications are added to the 3D model.

6. 3D-Simulation
   a. Detailed simulation models of the structural members of the Quad, Quad Pod, 5QuadPod and 5QuadCube will be evaluated.
   b. The models will be constructed with a sufficient number of nodes per structural member to define critical loads and critical interfaces.
   c. Finite element analyses will identify dynamic and static loads for various loading scenarios including dead weight, transportation loads and impact, vibration and fatigue and corresponding stresses experienced by the structural members.
   d. Appropriate adjustments will be made to these structural members in order to arrive at a structurally sound design for the Quad, QuadPod, 5QuadPod and 5QuadCube that may result in a fully integrated shipping platform.

7. Manufacturing Processes, Preliminary Costs and Business Case
   a. Definition of the manufacturing processes, potential manufacturers, sources of materials/raw materials and necessary lead times will be defined.
   b. Based on the design features, materials qualification and identification of manufacturing processes, a preliminary cost estimate will be prepared.
   c. A comparison of the costs and benefits will be prepared to show the Business Case.

Appendix E contains a list of the materials that are being considered for the development of the 5 QuadPod™ systems.

8.9 Commercial Market Place Evaluation

As a part of the experimentation project, the benefits of the 5QuadPod system to the various stakeholders in the less-than-truckload (LTL) and just-in-time (JIT) market will be researched. This includes the impact on:

- Drivers (drayage operators and line haul operators)
- Ease of access
- Warehouse operations considering the no load sequence
- Load distribution
- Security of cargo
- Shipper operations
- Loading docks
- Denser packaging/pallets
- Ease of sorting, storage and display
- Package to display capability
- In/out processing and efficiency of shipping and receiving
- Point of View - advertising in-transit
- Ocean Carrier friendliness
- Flexibility for route planning (no load sequence)

- Environment
- Fuel consumption
- Maintenance

8.10 Military Relevance Evaluation

The near term research and analysis to determine the military utility of the 5QuadPod System will be focused on its employment in support of the Joint Sea Based Logistics concept. SM21 will take the lead in conducting the modeling and simulation needed to determine the value of the system in this environment. Other military analysis and experimentation associated with the discussion below will occur during future years. Currently, SM21 is in the early stages of exploring the possibility of including the 5QuadPod System in a future year Joint Exercise sponsored by the Pacific Command (PACOM).

The 5QuadPod ™ concept supports the needs the Army, Navy, Marines and Air Force (the Services) have for unitized portable containers, selective off-loading from Sea Based Logistics support ships (T-AKE) and the ability to sense and respond. The "System" concept includes configurations that support packaging, sorting and storage functions, and that adapt to multiple transportation modalities and provide the vehicle for distribution and final product display.

The 5QuadPod concept addresses the tasks identified in the "Joint Standardized Packaging and Container Assessment" (JSPCA): A Joint Capabilities Integration and Development System (JCIDS) Perspective" as prepared for the Naval Sea Systems Command. The 5QuadPod concept supports the objectives of the Navy's Sea Base: to Close, Assemble, Employ, Sustain, and Reconstitute and addresses the issues outlined in the Joint Modular Inter-modal Distribution System (JMIDS) report FY06. The system concept also supports and enables the objectives of the SM21 JDDSP.

The Battlefield commander requires Total Asset Visibility (TAV) and In-transit Visibility (ITV) that compliments his need for speed and mobility. Additionally, Navy combat logistics support ships (T-AKE) will have to embrace new dimensions as supplies and munitions are prepackaged, consolidated and proportioned for rapid deployment and selective off-loading at a Sea Base. This will necessitate small, compact, light weight and more unitized shipping systems that can be quickly bundled together without banding, blocking and bracing or use of additional platforms.

The ideal platform will have to be intelligent, secure, and flexible with the ability to stand alone or quickly interlock to form more complex structures for packaging, sorting, storage, transportation (trailer, rail-car, barge, airlift or ship), distribution and display. The new logistics paradigm will have to be technology friendly to support the DoD ever increasing need for superior "Situational Awareness".

With the addition of smart RFID and an environmental sensory system (the Dynamic Smart Box™) the 5QuadPod™ will be able to automatically create an electronic cargo manifest, generate a deployment manifest and create a reconciliation manifest per Quad™. Each Quad™ and 5QuadPod™ will be able to sense and respond with other QuadPods™ in support of a Sea-base or Staging Area to provide real-time information and perform automated replenishment functions. Each Quad™ will be secured by a smart locking mechanism that will respond directly or through third-party authorization. With the 5QuadPod, a virtual Warehouse-in-Motion will be created.

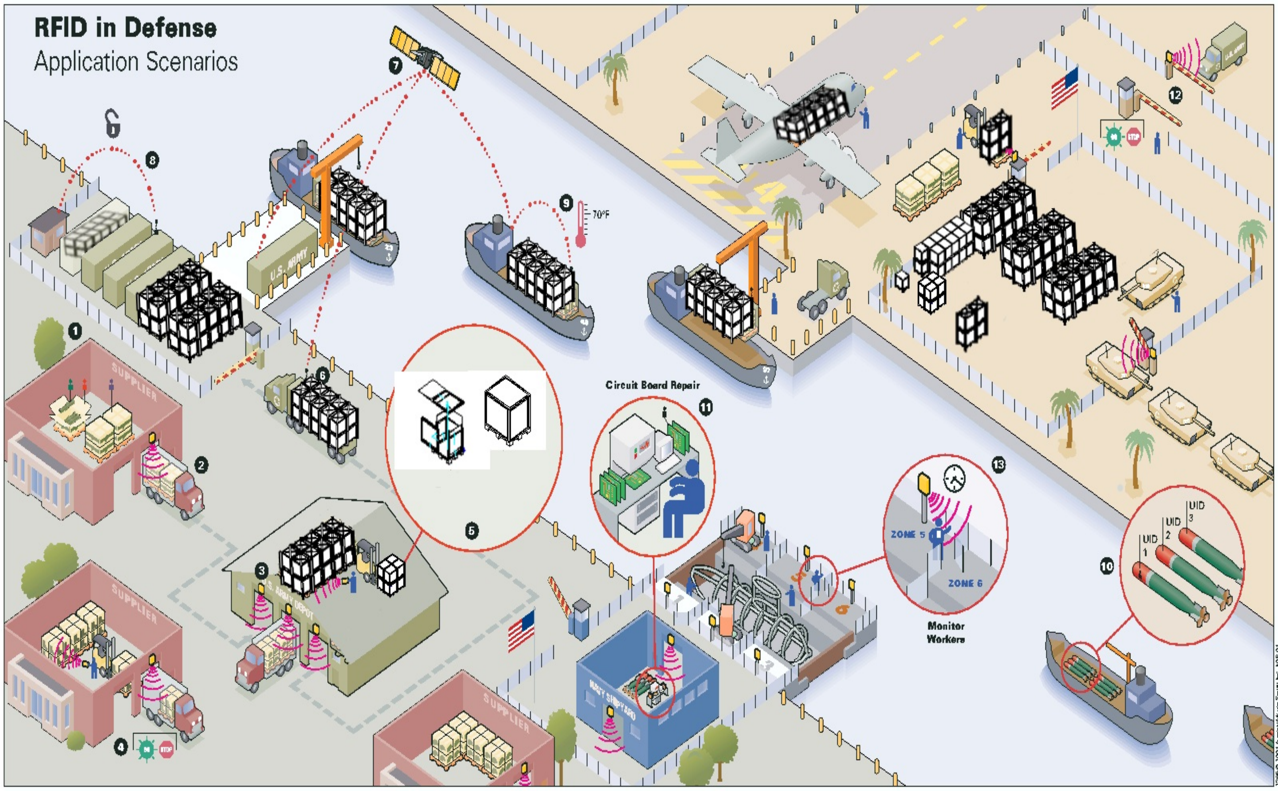

Figure 22: Modified from BearingPoint's "RFID in Defense: Foglifter"

8.11 Conclusions

The 5QuadPod™ experimentation process is designed to evaluate a new paradigm for military and commercial logistics. Experimentation will evaluate the design concept, which permits cargo to be loaded with minimal consideration for load-sequence (more flexible route planning, reduced need for fixed cross-docks). The ability to provide Customs with better access to hot cargo while isolating and protecting innocent cargo from inadvertent damage during inspections will be initially evaluated during the near term experimentation process. A primary experimentation objective is the validation of the design of the frames intended to reduce container weight by at least 50% and provide for a more distributed load (less chance of shifting and roll-over) through modeling and simulation. The commercial and military usefulness of the pallet, bin, and box designs to permit the use of light weight packaging materials and the ability to choose the right packaging material for the prescribed mission, will be validated through an initial discovery process.

The materials to be incorporated in the 5QuadPod™ and their ability to provide the required strength and versatility will be validated through finite element analysis supported by modeling and simulation. The ability to use materials that will be compatible with the latest intelligent technology (RFID, environmental sensors, and GPS) and offer resilience to chemical and biological agents as well as support incorporation of e-textiles and other sensors for detection of dangerous agents (e.g. explosives, drugs etc.) cold-chain management, and chain-of-custody will be evaluated. A discovery process will be conducted to validate the use of new composites that will offer light weight advantages with impact resistance and insulating properties will be completed.

The 5QuadPod™ concept represents a disruptive process and an innovative change in the way distribution occurs. The experimentation process will evaluate this new system and its anticipated improvement of less-than-truckload (LTL) and just-in-time (JIT) manufacturing processes. For the Military, experimentation will support the anticipated ability of the system to support Sea Based Logistics.

9.0 MILITARY EXPERIMENTATION CAMPAIGN PLAN

9.1 Overview

SM21 has been working closely with two CCDoTT programs related to military force deployment: the Agile Port System (APS) managed by TranSystems and Sea Based Logistics Optimization (SBLO) managed by LMI as depicted in Figure 23. The SM21 Technical Manager has been collaborating with both projects since their inception. Work to date on both projects has focused on concept analysis, workshops, data collection and analysis, and, in the case of APS, progressive capability experiments and demonstrations. The intent is to transition the information system development for the projects to SM21 once the initial discovery, modeling, business process reengineering, and capability demonstrations are completed and validated. Concurrently, SM21 is using the process designs developed under the APS project to design, develop, and experiment with the enabling information management systems and supporting technology.

Figure 23: Collaborative Force Deployment Projects

9.2 Agile Port System

The commercial capabilities of the APS have been developed and were demonstrated at the Port of Tacoma. The experimentation planning, execution, and analysis, along with planning for the full dual-use APS demonstration is documented in seven technical reports. The reports can be downloaded from the CCDoTT Agile Port project website[18]. Recently the APS project, supported by SM21, has entered into a multi-phased experimentation and demonstration

[18] Agile Ports and Terminal Systems web page located at: http://www.ccdott.org/content/DS_fr.html

agreement with the US Transportation Command as outlined in Figure 24 below. Phase 1 of the agreement has been completed. Currently Phase 2 is in the final stages of completion. At the end of Phase 2, the results will be provided to USTRANSCOM for review and approval of the Phase 3 full scale, dual-use demonstration of the APS system processes. This demonstration will not include integrated APS information management system since but will be focused on experimentation and validation of the revised business and functional processes required to support a dual-use APS system. After validating the APS business and functional processes, final development and integration of the force deployment services with the JDDSP SOA will be completed for testing and experimentation. Once the JDDSP Force Deployment Services have been validated, a full-system demonstration during a force deployment will be proposed to USTRANSCOM.

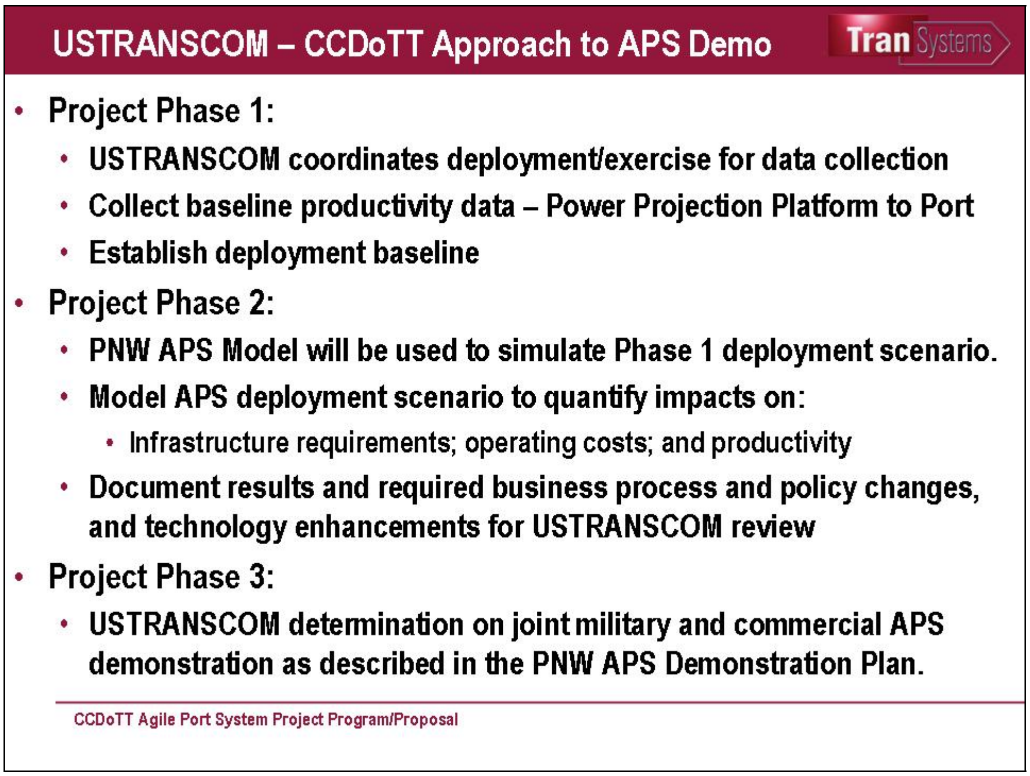

Figure 24: Three Phase Approach to the Agile Port System Demonstration

The SM21 Technical Manager supported the Agile Port Study in the collection of baseline force deployment processes and timed movement data. An evaluation of the collected data determined that military cargo is moved from inland points (Power Projection Platforms (PPP)) to debarkation points (Ports) without proper load sequencing. As a result of this sequential deployment process, there is a typical requirement to plan for the use of over 25 acres of commercial terminal land. The land is required to pre-stage military equipment for up to five days before beginning equipment loading operations. In an initial SM21 study, it was determined that significant savings of time, labor and expense will occur if concerned parties better coordinate and control the movement of military cargo from the PPP to the port and more diligently monitor the port dwell time of military cargo at the transition nodes.

SM21 will support the development of the revised business processes associated with load sequencing unit equipment flow from home stations (Power Projection Platforms) to arrive at the marine terminal in the correct loading sequence. During the 2008 experimentation phase, SM21 will begin to develop and perform experimentation with the algorithms and supporting software systems that will be integrated with current stow planning and information management systems to create an automated process of load sequencing, route planning, and dynamic replanning. In the near term, experimentation will be limited to a software laboratory environment.

9.3 Agile Port System Experimentation Hypothesis

If a deployment load sequence can be created for each piece of equipment from the fort to the ship stow location, and dynamically re-planned in a collaborative environment, then concurrent deployment processes can be employed, which will reduce ocean terminal land space requirements at strategic ports by 50%.

A visual representation of this meta-hypothesis is provided in Figure 24. The figure represents a typical force buildup at a strategic seaport using current state business and functional processes. As a result, between 12 and 30 acres of commercial port property is leased and occupied over a five to nine day period for a single ship load-out. The figure also depicts the positive impact of the future state APS processes which enables the movement of forces in the correct sequence for more of a "just-in-time" loading process.

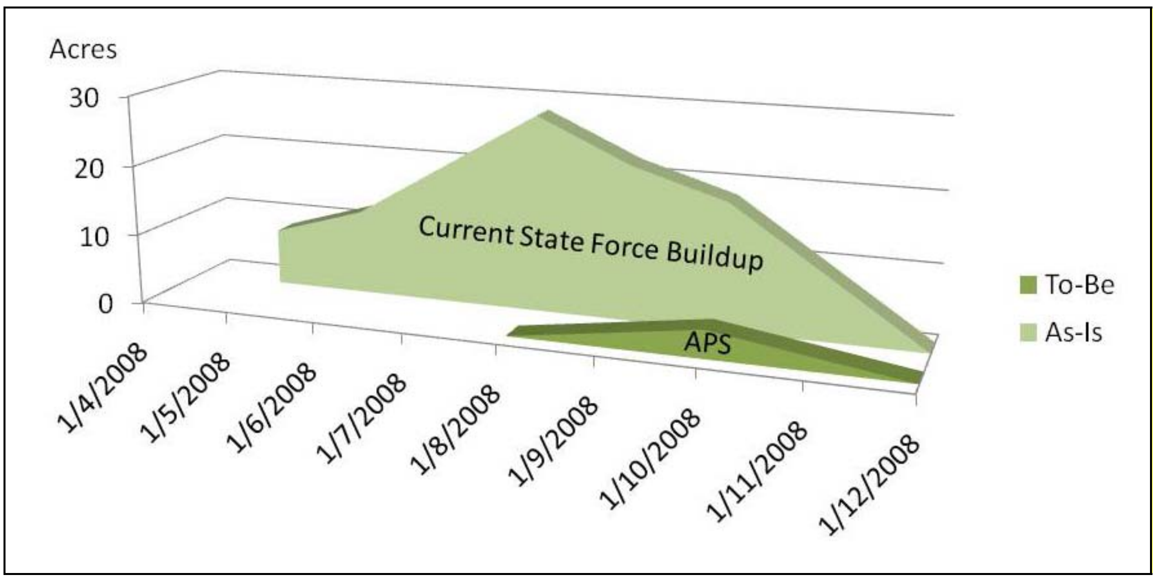

Figure 25: Military Force Port Buildup Comparison (As-Is and To-Be Processes)

9.4 Near Term SM21 Agile Port System Experimentation

As depicted in Figure 26, the near term SM21 APS joint experimentation with CCDoTT is focused on several discovery and development projects that will enable the more controlled flow of forces from home station to the individual equipment final ship stow location. The established design of the to-be processes requires the development of new algorithms to support the optimization of surface convoy movements; ship and rail loading processes; and the proper staging and movement sequencing of equipment at the transition nodes.

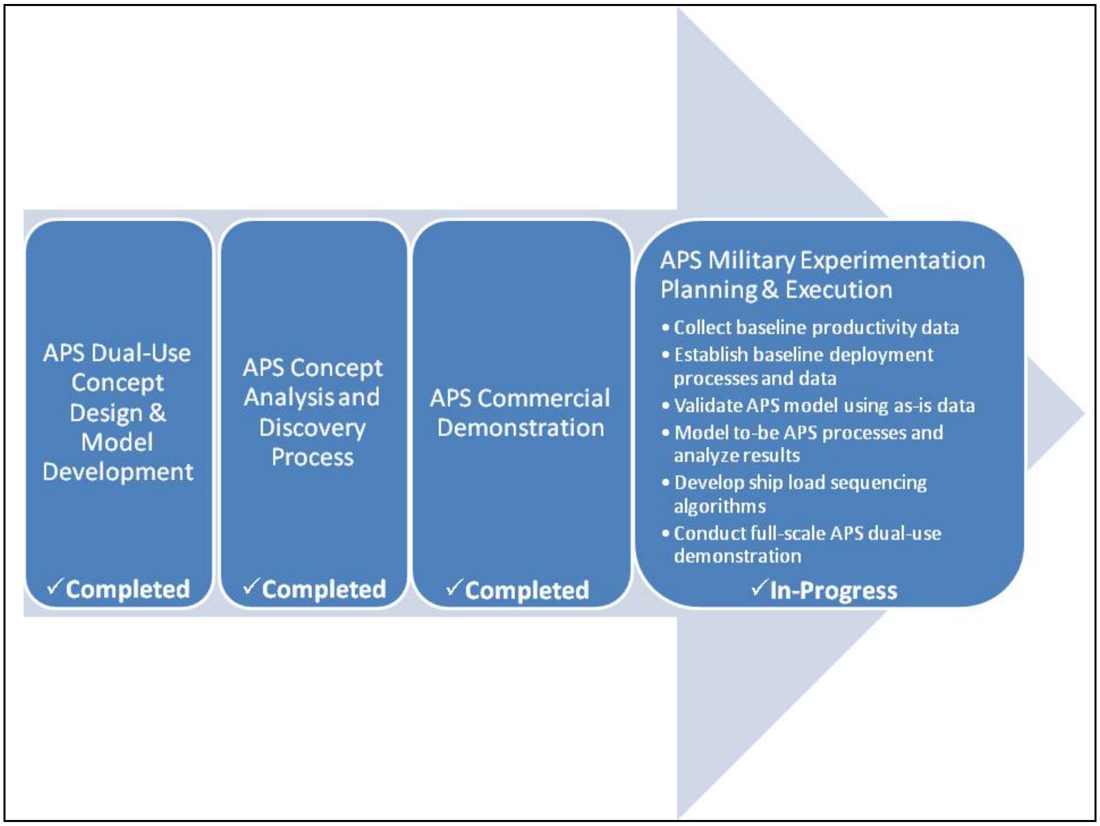

Figure 26: Agile Port System Experimentation Campaign Planning and Execution

As noted in Figure 26, most of the commercial business and functional processes have been validated through the CCDoTT experimentation campaign that is currently in the early stages of transitioning to the SM21 program. The SM21 near term military experimentation timeline and project planning will be documented in a full Project Management Plan. The tentative timeline for the longer term SM21 Agile Port System Campaign Plan is outlined in section 8.5.

9.5 SM21 Agile Port System Experimentation Campaign Plan

The tentative SM21military experimentation campaign plan timeline follows:

- March 4, 2008:
  - Based on the completed baseline force deployment analysis, begin development of revised force deployment processes
- March 28, 2008:
  - Begin development of load planning algorithm
- April 22, 2008:
  - Phase 3 CCDoTT decision brief to USTRANSCOM J5 (See Figure 24)
- August 15, 2008:
  - Begin desktop testing of load planning algorithm
- August 30, 2008:
  - CCDoTT completes full scale force deployment demonstration planning
- September 30, 2008:
  - Complete desktop testing of the basic load planning algorithm

- October 30, 2008:
  - Complete integration of the load planning service with the JDDSP SOA for initial testing
- January 2009:
  - Demonstrate basic load planning service to SM21 stakeholders
- February 2009:
  - Finalize agreements to work with TC-AIMS II and the Worldwide Port System to provide load planning support services
- March 2009:
  - Begin a six to nine month iterative experimentation process with TC-AIMS II, the Worldwide Port System, and ICODES
- Prior to start of winter 2009:
  - Support CCDoTT full-scale, dual-use APS process demonstration (JDDSP not included)
- TBD – Following full-scale APS demonstration:
  - Revise JDDSP SOA functionality as required based on CCDoTT APS demonstration results
- 2010-2011 time period:
  - Validate the JDDSP load planning service
  - Integrate the JDDSP as a component of a joint exercise focused on sea based logistics operations

Figure 27 provides a visual depiction of the JDDSP military force deployment initial operating capability development, experimentation, and continuous enhancement/improvement process.

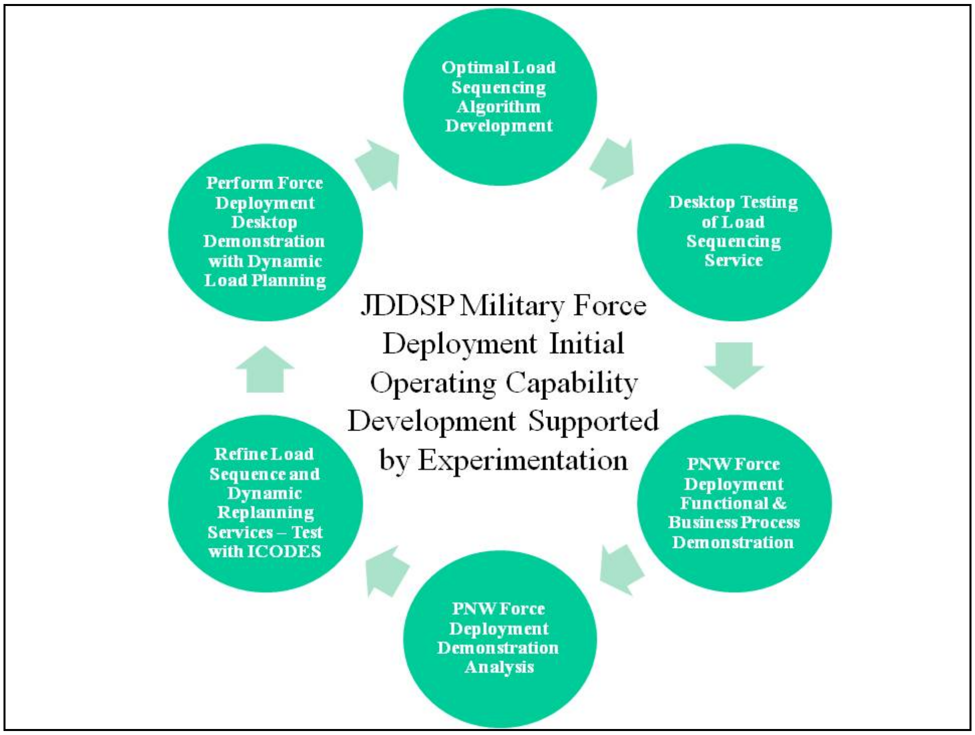

Figure 27: Force Deployment Initial Operating Capability Experimentation

9.6 Ship Load Planning Capability Development Using an Algorithmic Reference Model

As the Agile Port System project begins the transition to SM21, the focus will begin shift from proof of concept to experimentation with the enabling information management technology. The near term SM21 military force deployment experimentation will focus on the development, testing, and experimentation of an advanced load plan development capability for the JDDSP, the core operating capability of the APS. The algorithmic model for determining the optimal load sequence plan for military roll-on/roll-off ships used in strategic deployment will be described in detail in the military experimentation project management plan. The conceptual model overviewed in this document and expanded upon in the project management plan is intended as a start point for developing the JDDSP military force deployment load planning service. The algorithm development and desktop experimentation will be conducted during the initial year of the SM21 experimentation plan execution.

The load plan, or sequenced cargo planning process, would begin with a ship stow plan output file development by the Integrated Computerized Deployment System (ICODES). This ICODES output file would be an input to SM21 developed load sequencing and routing service. The load plan algorithm to be developed in the near term would order the flow of unit equipment (cargoes) from the ocean terminal staging area to the final ship stow location. Ultimately the algorithm would support the correct sequencing of unit equipment from home station motor pools to the final ship stow locations. The following sections provide a brief overview of the draft conceptual model.

9.6.1 Ship Load Plan Conceptual Model

Given an established ship node-arc network, based on the design of a specific ship, and a group of objects called cargo that must move in the network, it is natural to ask what is the best way for the cargo to move from their origins to their designated destinations commonly called stow locations. The SM21 ship-load plan service will employ a standard shortest path algorithm to successively determine least time paths for each cargo and the loading sequence for each piece of cargo. The algorithm is to be based on a least cost network flow algorithm which uses the fact that given a least cost flow of X units in a network, and given an incremental minimum cost path for one additional unit of flow, the original flow plus the least cost incremental flow is the least cost flow of (X+1) units. This approach to networks is taken since resource scheduling and node capacity constraints interrupt the flow. A key feature of the least cost flow approach is that it finds least cost paths in the incremental network; that is the network adjusted for the prior flows with negative cost flows representing a rescheduling of the prior flow. Since in a problem where cargoes are not interchangeable (stow locations will be established by ICODES)[19] the service would not reschedule cargo movements. The service would find the minimum time path for a cargo without interfering with any previously scheduled events in the network. The usual network flow algorithms would track the flow capacities of each arc; however, the SM21 developed algorithm is to track event capacities - each arc has a list of events. The algorithm is

[19] The objective will be to ensure that the stow factor of the ship meets the USTRANSCOM requirements for the overall force deployment requirements while reducing overall loading times and the requirement to stage an entire force before beginning ship loading operations. Generally, stow factors between 70 and 80 percent are considered adequate. The point is that ICODES will provide the optimal stow factor and the SM21 load planning optimization service will provide the best cargo flow paths, maximize concurrent loading, and provide the loading sequence for each piece of cargo without changing the optimized stow locations of the cargo.

to find the least time paths through a network of event lists indexed by the arcs. This would give each arc a discrete time dimension in unequal increments depending on the resource used for each arc traversal. The algorithm's basic decision would not be so much which arcs the cargo should use but which event to use if possible or which events to create to account for the cargo's movement. Within this framework of finding least time paths for each cargo the service should obey the following rules:

1. Each arc traversal would use a resource of the type specified by the arc. By tracking each resources usage this rule ensures that the service will account for the scarcity of resources.
2. Each use of a resource would obey the constraints associated with that resource in terms of arc and cargo compatibility.
3. When a cargo visits a node it must obey the physical as well as administrative constraints of that node.
4. Two cargoes would not occupy the same space at the same time. The service must enforce node capacity constraints and arc traversal separation constraints.

9.6.2 Algorithmic Summarized Description

The algorithm will be developed so that the order the service processes individual pieces of unit equipment will be associated with designated cargo priorities and zone dependencies. These priority and dependency mechanisms would be related to each other but would be used for different purposes and have different effects on service behavior. The cargo priority would be used to determine the sequence for the service to find each cargo's least time path to its destination. If the network structure allows multiple paths for cargoes the cargo priorities may not be strictly correlated with the cargo completion times. The zone table must have a group of fields defining a prior zone. Initially, each class of Strategic Sealift ship will be analyzed for proper hold and sub-hold zone loading order sequencing given the ship design. The service would be programmed not to schedule cargoes associated with the keyed zone (the dependent zone) until after the last scheduled movement associated with the prior zone (the independent zone). In order for the service to know the time all independent zone cargo have finished their movements, it will need to process all cargoes associated with that zone. One of the first things the service must do after reading the data is check this dependency between zone priorities and zone dependencies. There will always be a strict correlation between the zone dependencies and cargo completion times. Since the cargo table provided by ICODES would associate each cargo with a zone, the zones would partition the set of cargoes. The partial ordering of the zones defined with zone dependencies would also partially order the cargo partition sets. When the service would reset the cargo priority order it would extend this partial order from the zones to a full order which it would describe in the priority order field. There would be nothing to prevent the cargo priority ordering from being finer than the one derived from the zone dependencies as long as it is consistent.

The service will be developed to prevent a resource from traversing an arc by filling in a record in an “arc resource exclusion” table. This would restrict a resource to certain areas of the network because of the arc or resource attributes. Node capacities may seem to be the same thing as node constraints but a node capacity table would direct the service to perform a different set of procedures when processing information about the node. A node constraint would describe a single cargo's ability to move through a node. A node capacity would describe how much of some cargo unit of measure can accumulate at a node. If the service should not bother tracking the capacity of a node then the analyst would not enter a record for that node in the node capacity table. If the node cannot accept cargo without a resource the node capacity record for that node would have a zero capacity for any unit of measure. When there is a real constraint on how much cargo can accumulate at a node the analyst would enter the amount in the most constraining unit of measure. The service would create a list of events for the node. The service would keep track of each cargo arrival and departure event and ensure that it will never schedule an event which will exceed the node capacity. The service would have a hidden assumption here that if a cargo does not violate a node constraint it would not violate a node capacity.

At the heart of the conceptual design for this service is a procedure for finding a least time path for a single cargo. Several algorithms have been developed that can support solving the ship loading problem. For the start of the development and experimentation process, the reference model selected by SM21 will employ Dijkstra's algorithm with modifications. The significant modification is that it accepts an arc cost function as a parameter. This function evaluates the cost of an arc traversal. The service computes the time to traverse an arc as a function of the arc, pre-scheduled events for that arc, node capacity events, delays and resource availability. To compute when a resource can be available to move a cargo the Arc cost function would call the same shortest path algorithm to compute arc re-availability time but with a simple arc cost function as a parameter. The arc cost function controls this recursive use of the shortest path algorithm by storing resource repositioning times in an indexed list sorted by access frequency and retrieved by resource's last node and resource type.

9.7 The Way Forward

The next step in the military experimentation campaign plan is the development of the project management plan for the development of the ship load sequencing service. The plan will include the refinement of the functional processes associated with the APS demonstration and initial development of the ship load sequencing for the T-AKE in support of sea based logistics.

10.0 SM21 SEA BASED LOGISTICS DISCOVERY CAMPAIGN PLAN

Sea based logistics offers SM21 the opportunity to demonstrate the scalability and adaptability of concepts developed for the JDDSP. The JDDSP SOS architecture was designed to support the advanced base and sea based logistics, which extends the value of the JDDSP concepts.
The JDDSP architecture will fail to achieve its vision if it is unable to provide timely, actionable data to those responsible for the execution of the "on the ground" functions required to deploy forces and distribute sustainment. Actionable information exists in the cognitive domain and involves the process of collecting timely and accurate data and transforming this information to informed and timely actions in the physical domain. To ensure action level workers in the Sea Based logistics environment have the information available to make knowledgeable decisions, SM21 will conduct a number of experiments and demonstrations in the near term, that while not directly related to Sea Based Logistics, will support future experimentation directly related to sea base support concepts. Figure 28 provides an initial overview of the SM21 architecture proposed to support sea based logistics. The JDDSP SOS and cargo load sequencing services are being designed to include support for sea based logistics.

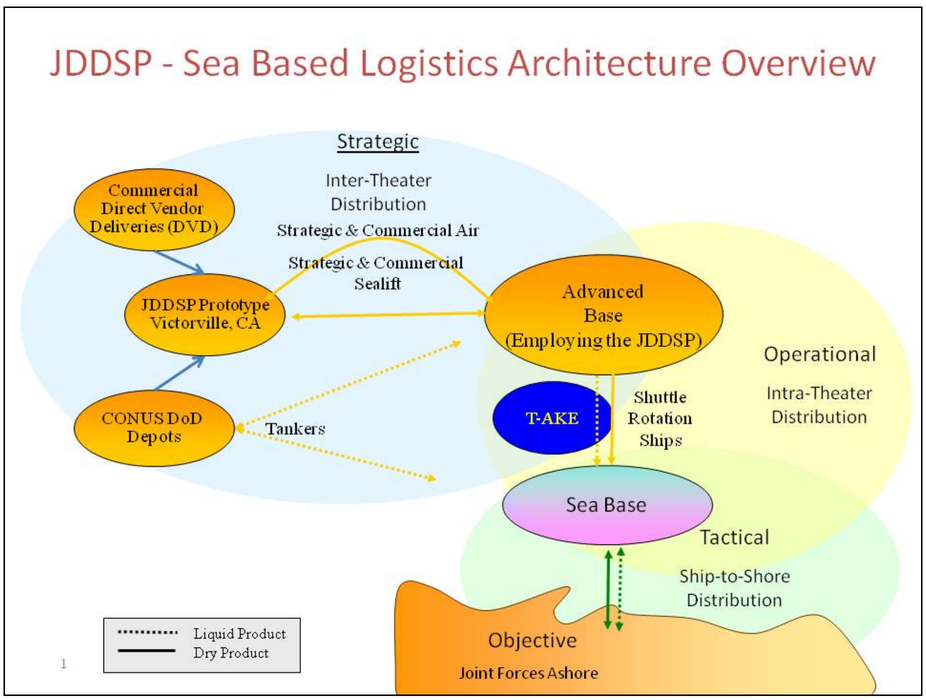

Figure 28: JDDSP – Sea Based Logistics Architecture Overview

During the current program year, working with military and commercial stakeholders, the initial design of IP-MTOPS was developed. This initial design, which is being revised and updated to ensure a more secure and scalable system, focuses on: optimizing logistics flows; supporting JDDSP facility security requirements, maintaining required throughput productivity; and providing high service quality to strengthen customer relationships. IP-MTOPS will be supported by dynamic load planning services, such as ICODES[20] and the SM21 ship load

[20] SM21 CLIN 0011, ICODES Extension Technical Plan

planning service, which will be designed to include support for T-AKE loading operations at the advanced base.

In addition to SM21 developing IT tools to track and manage shipments as they transit logistical nodes and trans-shipped among transport modes, research must be done to develop effective shipment packaging configurations. New packaging and shipment container designs that seamlessly move through deployment and distribution nodes and transfer between transportation modes are required to improve the factory to store distribution channels. SM21 has evaluated the utility of both the Joint Modular Intermodal Container (JMIC) and the evolving 5QuadPod™ system. Figure 29 provides an overview of the systems. Both systems provide more flexible packaging options that support the special needs of Seabasing for:

- Selective on-load/offload of shuttle ships and connector vessels like the T-AKE
- Strike up/Strike down operations, particularly in high sea states
- At sea cargo transfers (Skin to Skin transfer)
- Capabilities of current and future combat operations to handle delivered goods

Figure 29: Alternative Packing and Shipping Containers

The SM21 experimentation campaign plan has been established to support the development of the JDDSP SOS architecture. The experimentation will be supported by extension of the SCASN model to include support for the evaluation of the required SM21 Sea Based Logistics Architecture. The experimentation plan will include development of the JDDSP SOS architecture, advanced sustainment packaging and distribution systems, and will culminate in a future year demonstration of the packaging and JDDSP capabilities in a Joint Seabasing exercise. Figure 28 provides a high level overview of the transportation and sustainment pipeline that the JDDSP would support during a Joint exercise. As depicted, the pipeline would originate at the CONUS source to the JDDSP prototype site in Victorville, CA and would end with the loading of supplies on a T-AKE at the advanced base. The JDDSP architecture would support the key supply and demand nodes.

10.1 Sea Based Logistics Experimentation Hypothesis

If a new modular packaging system supported by dynamic stow and load planning services, can be built, then four logistic support ships (T-AKE) will be able to sustain two deployed joint brigades through a sea base located up to 2,000 nautical miles from the advanced base[21].

10.2 Way Ahead

Since the sea based logistics demonstration will be the SM21 JDDSP experimentation campaign plan capstone event, as depicted in Figure 1, the sea based logistics campaign plan has been more fully developed in a separate technical report. The sea based logistics development and experimentation plan is more fully developed in a separate SM21 technical report. In addition to the technical report, a project management plan for near term sea based logistics experimentation will be developed. Since the sea based logistics capstone demonstration will be built upon prior dual-use experimentation, the project management plan will document how each SM21 experiment supports the capstone demonstration.

As an example, the sustainment of two deployed joint combat brigades through the sea based logistics architecture, as depicted in Figure 28, will require all of the capabilities nominated for experimentation by SM21. This includes a dynamic ship load planning service, advanced packaging systems, modal diversion capabilities, and supply chain distribution practices that respond to each Class of Supply independently based on the functional or innovative nature of the products. As depicted in Figure 30, knowing the requirement sustainment as soon as it is known and then subsequently dynamically managing the distribution pipeline will reduce overall cost and achieved a significantly higher demand satisfaction rate.

During the commercial supply chain experimentation processes, the impact of functional and innovative products on the supply chain “deliver” functions will be studied. Lessons learned will be applied to military supply chains. The most challenging military supply chain from a “deliver” perspective will be the support of deployed forces through a Sea Base. This is the rationale for SM21 picking the Sea Base as the capstone JDDSP demonstration.

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[21] The T-AKE support ships will shuttle supplies from the advanced base to the sea base. The T-AKE would remain on station at the sea base until their supplies reached a safety level at which time they would return to the advanced base for reloading. The T-AKE would act as a floating warehouse discharging the correct mix of supplies by Class on a just in time pull basis versus employing a push basis.

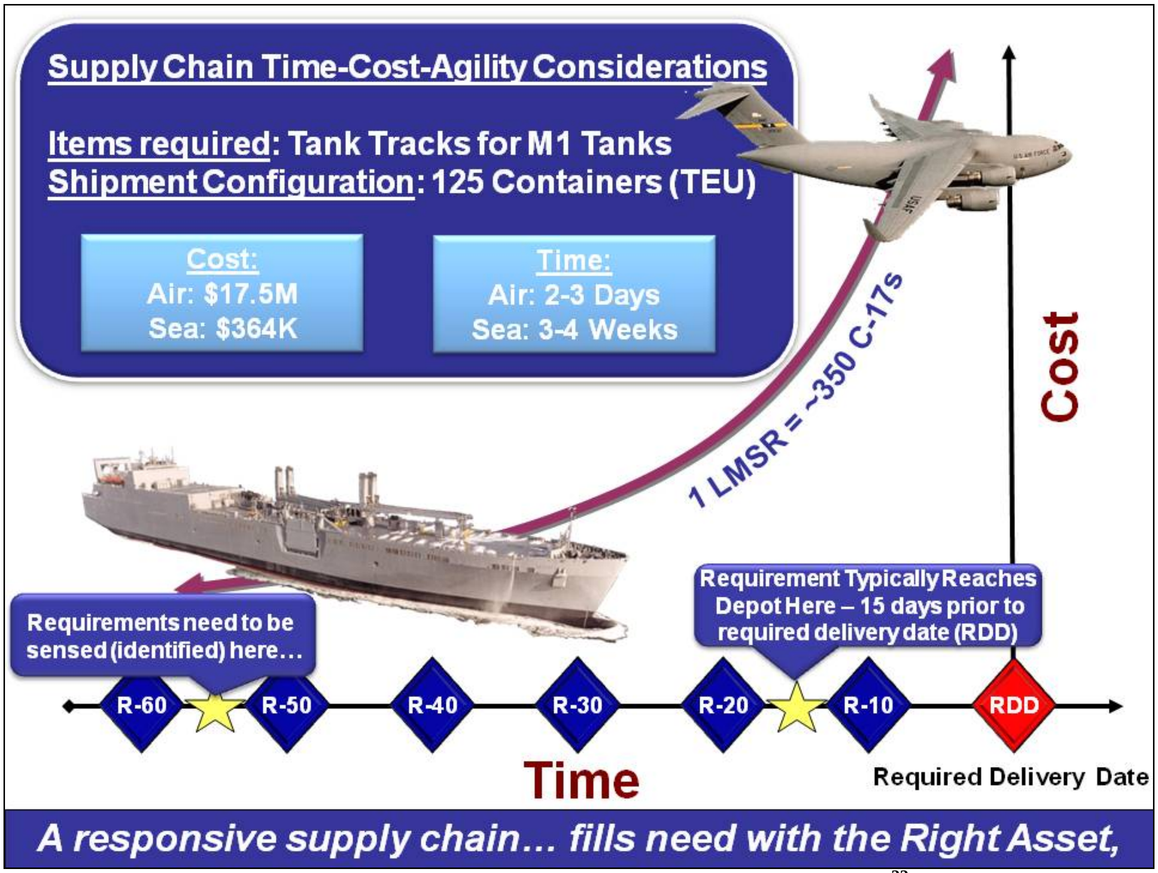

Figure 30: Supply Chain Responsiveness Considerations[22]

A definition of supply chain product characterization adapted by SM21 follows[23]:

- **Functional Products**: Include commercial staples that people buy in a wide range of retail outlets, such as grocery stores. For the military this would equate to Class I subsistent including the range of food starting at meals ready to eat (MRE), through semi-perishable, to perishable fresh food. Because such products satisfy basic needs, which don't change much over time, they have stable, predicable demand and long life cycles. Functional products require cost effective but reliable, quality delivery partners within the supply chain.
- **Market Responsive Products:** Innovative, market responsive products in the commercial sector include products that many companies introduce to avoid low profit margins. Fashion and technology innovations are added to give customers an additional reason to but their offerings – everyone needs the latest and greatest clothing line or computer. These products have volatile demand and require a fundamentally different supply chain than stable, low-profit margin functional products. For the military, an example of a market responsive product would be Class VIII medical supplies. The need for medical supplies is very unpredictable prior to the commencement of fighting and the

[22] Selected data taken from the USTRANSCOM Joint Exercise Program Overview developed by COL Stan Wolosz
[23] Harvard Business Review on Managing the Value Chain, "What is the Right Supply Chain for your Product?"; Marshall Fisher, pp. 127-154

> introduction of forces to a foreign environment. After engagement and over the life of the deployment conditions change and the demand for different medical supplies changes. Innovative and market responsive products require that delivery partners be selected primarily for speed, responsiveness, flexibility, and quality. The cost of distribution is a much lower metric to be considered.

The misalignment and of supply and product strategies can result in waste and great dissatisfaction among customers in both the commercial and military sectors. Aligning the product to the proper distribution processes, assets, and network is not an easy function but this careful, dynamic alignment is an absolute requirement for Sea Based Logistics.

11.0 SUMMARY

This Technical Report was designed to establish the initial Strategic Mobility 21 experimentation campaign plan. As presented in this report, the experimentation campaign plan is designed to support the deployment of the initial operating capability of the Joint Deployment and Distribution Support Platform (JDDSP). This initial plan is a living document that will be updated periodically during the execution of the experimentation campaign. For long term experimentation planning, SM21 has incorporated the general guidance provided by the Office of Force Transformation and US Joint Forces Command (JFCOM). The concepts that are the foundation of logistics transformation, which are documented in the Focused Logistics - Joint Operations Concept (JOC); the Joint Logistics (Distribution) Joint Integrating Concept (JIC); the Joint Sea Basing JIC; and the Sense and Respond Logistics JIC have been incorporated as appropriate.

SM21 considers itself a learning organization is that collaborative and adaptive. Our experimentation and development process depicted at a high, conceptual level in Figure 31 reflects this evolving corporate culture.

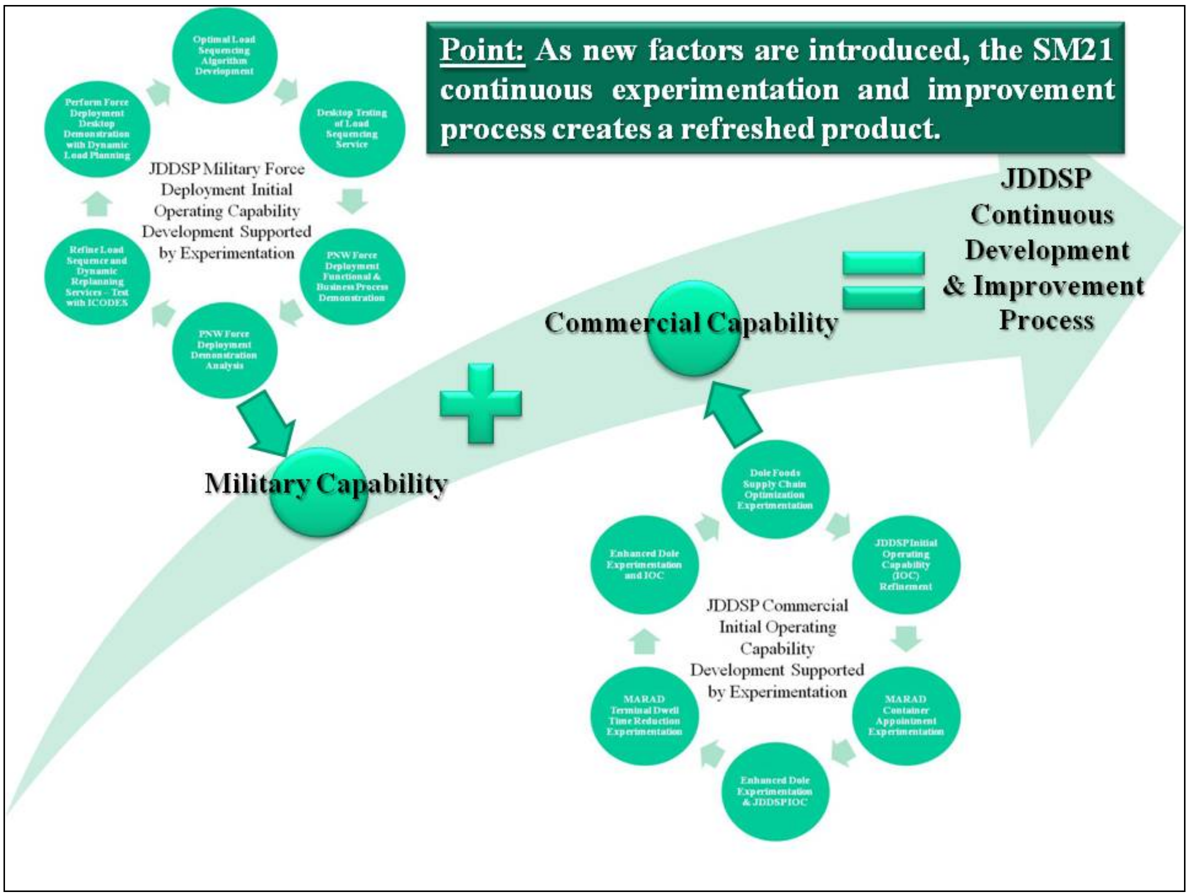

Figure 31: The SM21 Continuous Experimentation and Product Improvement Process

APPENDIX A: Literature Review

Alberts, David S. and Richard E. Hayes. *Experimentation: Code of Best Practice*, Command and Control Research Program (CCRP), Information Age Transformation Series

Alberts, David S. and Richard E. Hayes. *Campaigns of Experimentation*: *Pathways to Innovation and Transformation*, Command and Control Research Program (CCRP), Information Age Transformation Series

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APPENDIX B: SM21 Research, Experimentation, and Campaign Concepts and Strategies

B-1.0 Introduction

This appendix is intended to provide a summarized overview of the basic body of knowledge associated with research, experimentation, and joint military experimentation campaign strategy that will be applied to the design and execution of JDDSP experiments. The material in this appendix compliments and amplifies Sections 3 and 4 of the basic report. The appendix includes some basic processes adapted by SM21for gathering of data, analyzing the data, presenting the data, and the use of mathematical and business process models. The review provides the fundamental information required to develop an effective experimentation project management plan for designing and executing individual JDDSP experiments and the discovery of new technologies and processes that would improve the JDDSP concept. This appendix will be available on an SM21 maintained collaborative project website along with other supporting experimentation data and documents to add to the SM21 body of knowledge. Links to related on-line sources of information is also provided at the same location. The purpose of maintaining this appendix and supporting references within a collaborative environment is to allow the entire team to enhance our research and experimentation concepts.

Experimentation provides SM21 an opportunity to explore new concepts while employing an effective risk management approach. When properly conceived and executed, campaigns of experimentation should strike the proper balance between innovation and risk. But to strike this balance the team will require a common understanding of the objectives and processes associated with the SM21 experimentation campaign plan.

B-2.0 The Basic Elements of SM21Research and Experimentation

Since the basic terms associated with research and experimentation different meanings depending on the context and understanding of those employing the processes, it is important to define these terms in the context of the SM21experimentation campaign plan. First, SM21 experimentation is considered a coordinated process and not a collection of random experiments of opportunity. The SM21 experimentation process combines and structures the results of individual experiments in much the same way as individual building blocks are laid into a structure. Second, the results of individual experiments will also steer future experiments. For SM21 the individual experiments will build the system of systems architecture for the JDDSP. This structure will require experiments related to dual-use information technology, intermodal hardware, packaging, communication and tracking technology among others.

To mitigate the risk of learning the wrong lessons from a single experiment, SM21 will conduct continuous experimentation under varying conditions in order to better understand the real needs of the SM21 stakeholders. It is important that the results achieved in one experiment can be replicated under the same or similar conditions in other experiments before the results can be considered reliable. Therefore, the SM21 experiments, which will be largely transformational in nature, will be part of a planned series of experiments and related activities as defined in this technical report. The strategy used to develop the SM21 Joint Experimentation Campaign plan is provided in this Appendix. The objective of the SM21 experimentation campaign is to avoid the risk of making final development decisions without sufficient evidence and understanding of the requirements and technology required to satisfy the identified requirements. While many on the SM21 team have vast experience in both basic scientific research and operational logistics, the team must consider the following thought: "Experience is both a virtue and a curse"[24].

B-3.0 Comparison of Experiments and Experimentation Campaigns

The following table provides a comparison of a single SM21 experiment and the long term experimentation campaign.

	Experiment	Experimentation Campaign
Threads of investigation	Involves single event or axis of event	Involves multiple events and multiple axes of investigation
Organizing Framework	Organized around set of specific hypotheses	Organized around a broad goal
Analytic Goal	Provides focused testing of specific set of questions	Provides knowledge across broad set of issues
Number of decision points	Executes a specific experimental design	Has multiple decision points for refining issues and analyses
Number of factors	Measures impact of few factors while controlling others	Assesses relative importance and impact of many factors
Scenarios	Selected to provide best set of specific hypotheses	Examines a range of contexts to develop generalized predictions
Methodology	Employs selected methods and metrics	Employs a broad range of methods

Table B-1: Experiment and Experimentation Campaign Comparison

An experiment typically involves a single event or series of events designed to address a specific thread of investigation. An experimentation campaign involves multiple components (limited objective experiments, integrating experiments, and simulation experiments) conducted over a period of time to address multiple axes and vectors of investigation. Each axis or vector manipulates some attribute or aspect of joint force capability (collaboration, networking of C2, SRL) while controlling others. Together these axes and vectors contribute to the broader picture of logistics transformation potential. Experimentation campaigns best demonstrate the concept of synthesis of the systematic integration of causes and effects into improved actionable knowledge (knowledge management).

Experiments best achieve their objectives by tailoring scenarios to provide the best set of conditions for assessing selected issues or set of hypotheses. Scenarios can vary in echelon (strategic, operational and tactical). Most of SM 21's military experiments will operate in the joint world at the operational and tactical levels. Level of complexity will likewise follow a joint

[24] Campaigns of Experimentation: Pathways to Innovation and Transformation, a Code of Best Practice, Albert and Hayes, p.26

path of joint operations and effects based operations. Various levels of outcome measurement (situation awareness, force synchronization, and mission effectiveness) will be employed.

The SM21 experimentation campaign space will incorporate modeling and simulation, desktop exercises and live exercises or demonstrations to augment planned experiments.

B-4.0 Processes of Experimentation

Four phases of experimentation have been identified for building successful capabilities. At the start ideas need to be formed based on the identification of capability gaps. The next step is recognition of the potential of the ideas identified through concept development. Third, the ideas need to be formulated into innovations that can be refined, explored through experimentation, and matured. Finally, ideas need to be implemented (transitioned)[25].

The SM21 campaign of experimentation is centered on the requirement to develop and test the initial operating capability of the JDDSP systems-of-systems architecture. The conduct of properly designed and sequenced experiments is integral to the development of the IOC. The SM21 development of the JDDSP is currently in the third phase of experimentation as defined above. Once the JDDSP IOC has been established it will be possible to refine the JDDSP IOC through experimentation and matured. It is possible that after the initial year of experimentation the JDDSP will be commercially deployed for limited implementation.

B-4.1 Three Purposes for SM21 Experiments

As mentioned elsewhere in this report, there are three purposes for experiments: discovery, hypothesis testing, and demonstration. The three types of experiments serve to complement and build upon one another in the conduct of a campaign of experimentation. Hence, they have and will continue to contribute in their own way to creating and refining the JDDSP and disseminating knowledge.

- **Discovery experiments** are designed to generate new ideas or ways of doing things. They provide the opportunity to be creative and "think outside the box". Discovery experiments provide SM21 an opportunity to develop promising alternatives to current distribution management processes and systems and to develop them to the point where their potential can be assessed realistically as is the case with the JDDSP. As with the JDDSP force deployment capability development, it is important that a new processes or systems be adequately refined before it is compared to current practices or doctrine. If it is not, then the experiment will be focused on testing an immature and incomplete application capability. Discovery experiments provide the ability to explore and future define immature concepts. The product of a discovery experiment is a promising idea or approach. Discovery experiments do not necessarily involve the formal control of a set of variables (to isolate influences and effects); however, they do need to provide enough data so that the "promising" approach can be compared to the status quo. Discovery experiments can help to ensure that the campaign considers a full range of alternatives and does not prematurely narrow the alternatives. Successful discovery experiments can lead to either hypothesis testing experiments or capability demonstrations.

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[25] Campaigns of Experimentation: Pathways to Innovation and Transformation, a Code of Best Practice, Albert and Hayes, p.54

- **Hypothesis testing experiments** seek to falsify specific hypotheses (specific if—then statements) or discover their limiting conditions. They are also used to test whole theories systems of consistent, related hypotheses that attempt to explain some domain of knowledge) or observable hypotheses derived from such theories. In a scientific sense, hypothesis testing experiments build knowledge. It is generally accepted that multiple experiments of this type are needed to develop quality data in sufficient quantities in order to provide a foundation for confidently establishing new knowledge. Depending on the nature of the hypotheses tested, this type of experiment provides "proof " that a theory, idea, or approach is valid; establishes its value under specific conditions; establishes the exceptions and limits of its application or utility; and establishes a degree of credibility.

- **Demonstration experiments** create a venue in which known truth is recreated. These are like the experiments conducted in a high school in which students follow instructions to prove to themselves that the laws of chemistry and physics operate as the underlying theories predict. The SM21 Sea Based Logistics Capstone technology demonstration falls into this category. Demonstrations will be used by SM21 to show potential stakeholders that the JDDSP can improve efficiency, effectiveness, and shipment velocity. In successful demonstrations, all of the technologies employed are well-established and the setting (scenario, participants, etc.) is orchestrated to show that these technologies can be employed effectively under the specified conditions. Immature technology or inappropriate settings or scenarios will fail to achieve the desired result. Thus, demonstration experiments are designed to convince, educate, and (at times) train.

B-4.2 Analysis

SM21 has assembled a team of analysts from industry, government, and academia. These analysts will take the data provided by experiments, combines it with previously collected data, and develops findings that serve as the basis for drawing conclusions related to the logistics issues or questions at hand. Statistical theory forms the scientific basis for determining the probability that the observed data have a given property (e.g., two treatments are significantly different) with a given level of confidence, or in other words, that there is little likelihood that the result occurred by chance. This analysis will extend into areas of complexity where analysis is more challenging and will require new approaches and tools to identify emergent behaviors and system properties. Analysis will take place before, during, and after the conduct of each experiment. The conceptual model, Figure B-6, provides a framework and point of departure. There are many analytical techniques that can be brought to bear and care must be taken to employ the appropriate method or tool. The findings developed in each of the analyses that are conducted will be used to update the conceptual model and will be disseminated to others engaged in the campaign or related campaigns.

Key to Experimentation: Correlation Analysis

- Correlation Analysis: A group of statistical techniques used to measure the strength of the relationship (correlation) between two variables.
- Scatter Diagram: A chart that portrays the relationship between the two variables of interest.
- Dependent Variable: The variable that is being predicted or estimated.
- Independent Variable: The variable that provides the basis for estimation. It is the predictor variable.

Figure B-1: The Key to Experimentation: Correlation Analysis[26]

B-5.0 Experimental Design

While basic concept development, discovery, and demonstrations are generally understood, the setup and design of hypothesis experiments is worth more detailed review. To begin it is important to know what basic concepts are included and a definition/description of each concept.

Hypothesis testing experiments are typically used by researchers to advance knowledge by seeking to falsify specific hypotheses (specifically if - then statements) or discover their limiting conditions. For SM21 they will be used to test the whole JDDSP concept (systems of consistent, related sub-hypotheses that collectively define the JDDSP SOS). Figure B-2 provides a depiction of the SM21 “Hypothesis Tree”. This format will provide a structure for the experimentation teams to establish the meta-hypothesis and the supporting sub-hypotheses. The hypothesis tree will be completed during development of the project management plan for each individual experiment.

[26] SM21 Business Road Map: Part 7 – Experimentation and Demonstration, a briefing by Dr. John Hwang, February, 2008

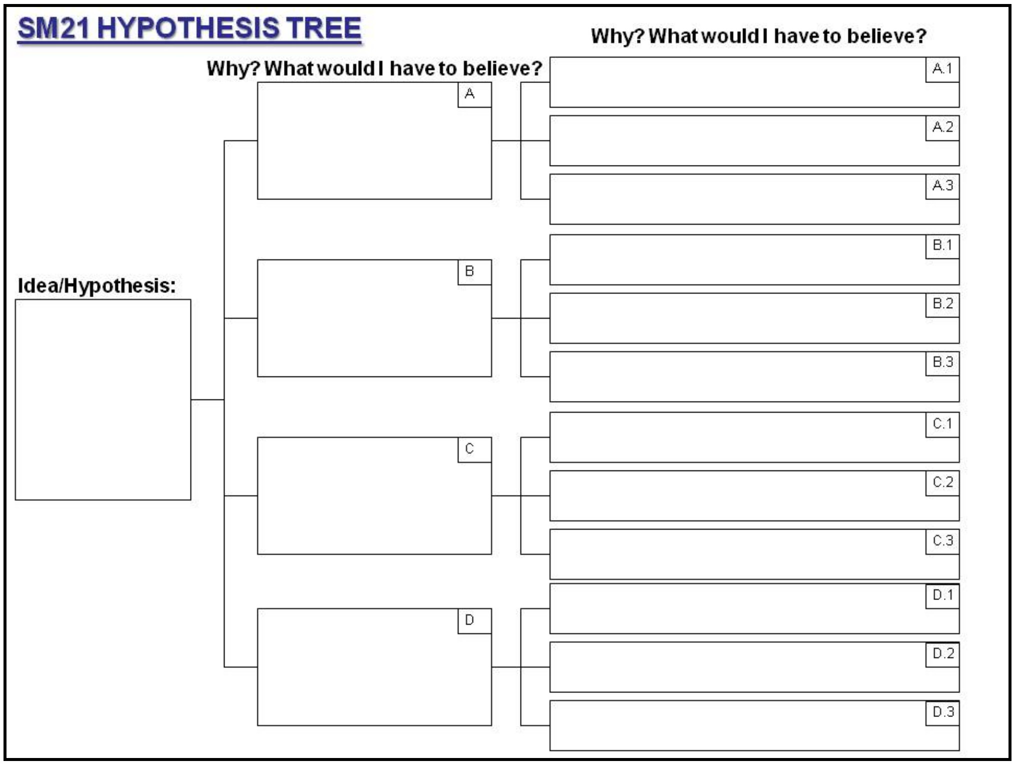


Figure B-2: SM21 Hypothesis Tree

In a scientific sense, hypothesis testing experiments will build the knowledge required to refine the understanding of the JDDSP domain. In order to conduct hypothesis testing experiments, the SM21experimentation teams will create situations in which one or more factors of interest (dependent variables) can be observed systematically under conditions that vary the values of factors thought to cause change (independent variables) in the factors of interest, while other potentially relevant factors (control variables) are held constant, either empirically or through statistical manipulation[27].

[27] Command and Control Research Program (CCRP), Information Age Transformation Series, Code of Best Practice: Experimentation, David S. Alberts, Richard E. Hayes. p. 22

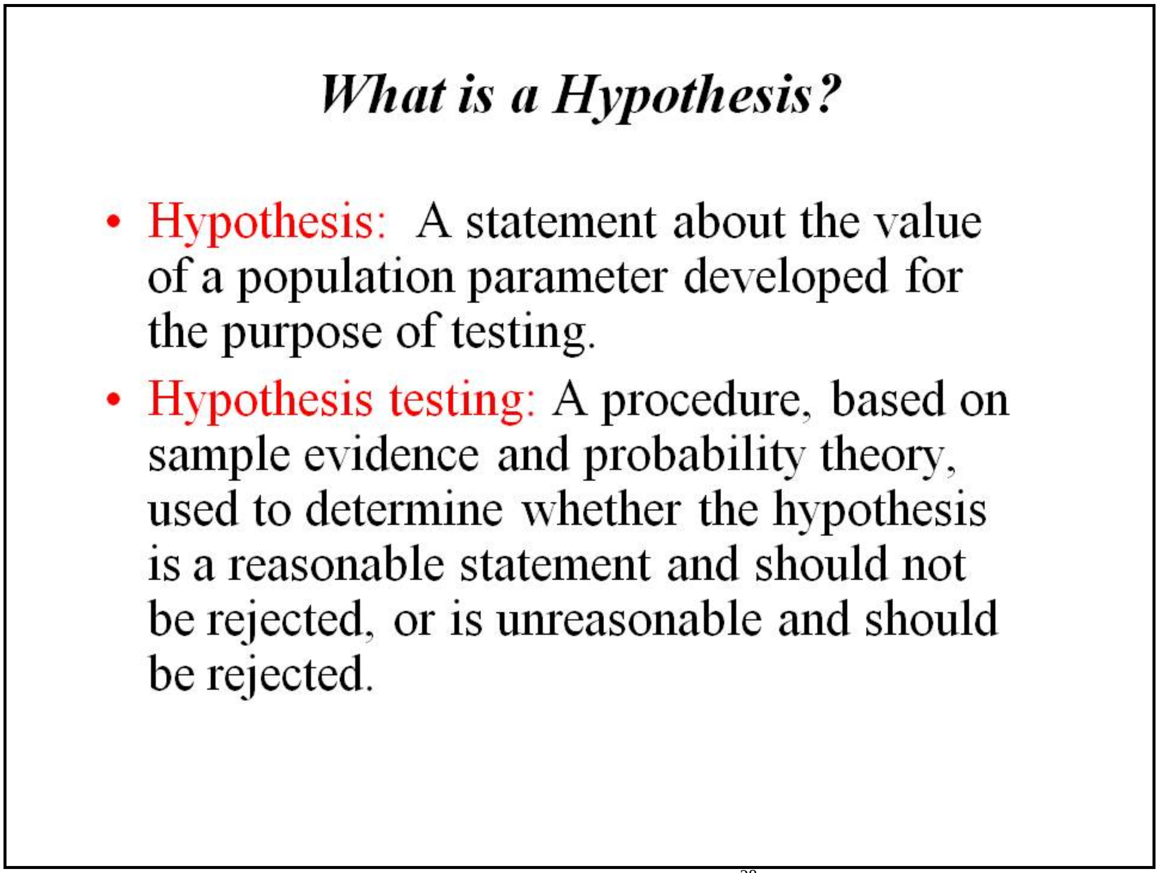


Figure B-3: Hypothesis Testing[28]

Figure B-3 provides an overview of hypothesis statements and testing. In Figure B-4, the five steps in hypothesis testing are presented.

The basic concepts involved in hypothesis experiments are summarized below:

- **Hypothesis:** A hypothesis is an educated guess about the relationship between the variables that can be tested (e.g. If marine terminals are able to prepare containers for movement off-terminal upon their discharge, then terminal throughput would be increased by up to 300 %.")
- **Independent Variable (IV):** An IV is the variable that is purposefully changed by the experimenter (e.g. containers are loaded on a chassis or railcar for immediately upon ship discharge).
- **Dependent Variable (DV):** A DV is the variable that responds to the change in the IV. (e.g. Acreage available on the terminal.)
- **Constants (C):** Constants are all factors that remain the same and have a fixed value. (e.g. number of import containers arriving on the same day, through the same terminal.)

[28] SM21 Business Road Map: Part 7 – Experimentation and Demonstration, a briefing by Dr. John Hwang, February, 2008

- **Control:** The control is the standard for comparing experimental effects. (e.g. Established baseline daily available acreage available when containers are grounded and stacked.)
- **Repeated Trials:** Repeated trials are the number of experimental repetitions, objects, or organisms tested at each level of the independent variable. (e.g. X containers over X days are immediately loaded on shipping assets.)
- **Experimental Design Diagram (EDD):** An EDD is a diagram that summarizes the independent variable, dependent variables, constants, control, number of repeated trials, the experimental title, and hypothesis.
- **Levels of the Independent Variable:** Some experiments may require the identification of levels of the independent variable. For example, the percentage of containers arriving in blocks destined for an out of region location ("rail-on-dock intermodal ready"). Decisions about the number of levels and the amount of each level must be made.

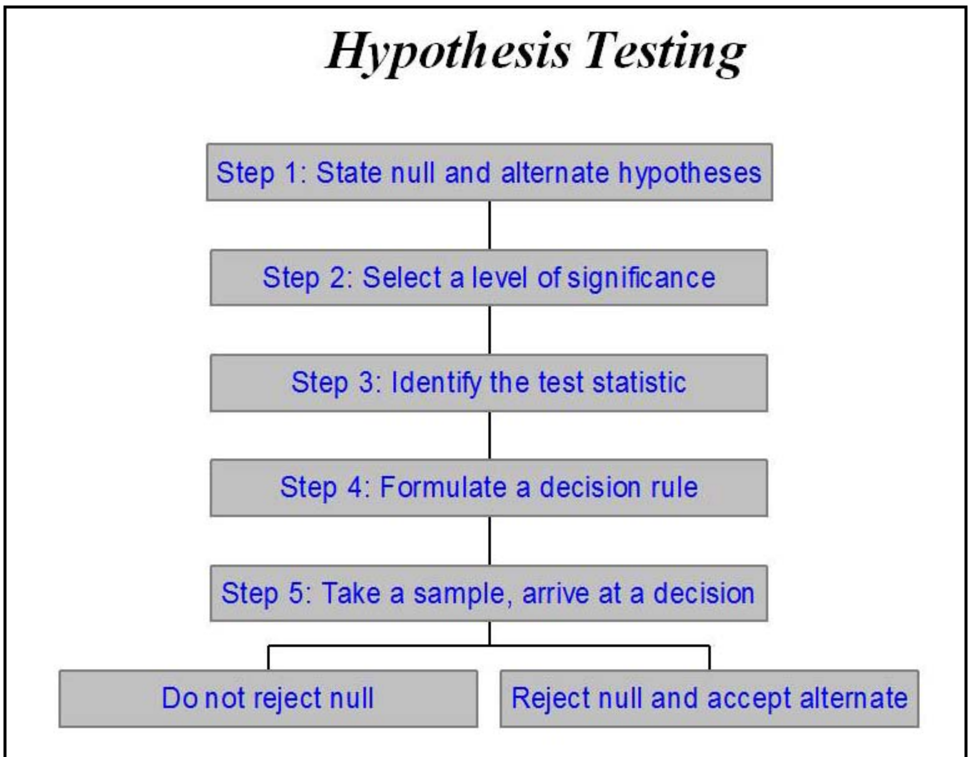


Figure B-4: Hypothesis Testing[29]

B-6.0 SM 21 Joint Experimentation Campaign Strategy

B-6.1 USJFCOM Joint Logistics Experimentation Model

To accomplish all the goals described in the Focused Logistics Campaign Plan, DOD is engaged in a wide-ranging process of experimentation and exploration. USJFCOM's Joint Experimentation Campaign Plan organizes experimentation around explorations of commercial off-the-shelf technologies that can improve the existing military force in the near term; emerging

[29] SM21 Business Road Map: Part 7 – Experimentation and Demonstration, a briefing by Dr. John Hwang, February, 2008

concepts, information systems, and technologies that will support the evolution of the force during the next decade; and revolutionary concepts and technologies that have the potential to completely transform the force.

The following bullet points overview the elements associated with SM21 Joint Logistics Experimentation:

- **Requirements Capture Methods and Procedures:** The customer requirements needed to define a cogent experimentation plan come largely from detailed interviews with key stakeholders. Network centric requirements are relatively un-documented to date. Models, formats, and templates will be reviewed for their applicability. To be network centric compliant, the NCOIC Kiviat Spider Diagram Model and the ASD-NII Network Centric Checklist will be considered for applicable aspects of the SM21 project.

- **Architectural and Business Process Artifacts:** The Department of Defense Architectural Framework 2.0 (December 11, 2007) will be used as the reference architecture for joint experimentation. (Artifacts include all views or AVs, operational views or OVs, technical views or TVs, and systems views or SVs) In order to limit confusion and miscommunication, the established language of infrastructure architecture is the foundation for this experimentation plan.

- **Domain Defining PFC is a (Protocol Functional Collection):** The PFC defined as the list of protocols, data models, standards, gateways, etc. needed by network designers and architects to prevent duplicative efforts. The JDDSP information infrastructure being developed uses Web services in a service oriented architecture framework. Other traditional legacy, flat file, and point to point architectures are also utilized.

- **Operational Activity Process Mapping:** The JDDSP process map shows the deployment and sustainment process and the graphical depiction of activities through the JDDSP and from each end of the network. It serves as the foundation for operational activities performed for government stakeholders to deploy and sustain forces and first responders.

- **General SM21 Regional Deployment Scenario Development:** The general regional deployment scenarios describe the potential operational scenarios for each of the key ports in Southern California. The Long Beach deployment scenarios are identified as surge sustainment operations. Currently the ports of Los Angeles Long Beach are seldom selected as deployment ports of embarkation because of port congestion related to the volume of import cargo. However, employing the JDDSP, based on a service oriented architecture, the Stryker brigade could more easily be deployed through either port. San Diego is the other primary Southern California ports for deployment. Deployment scenarios for these and all Southern California ports have been developed and are available on the SM21 PMIS. The following terms are applicable to the regional deployment scenarios:

- **Domain Mission Threads** define the regional operational activities through the JDDSP and surrounding nodes. Logistics mission threads developed by JFCOM and others will be considered for use and for rollup on this project. Understanding the mission threads provides part of what is needed to form a control sample. Experimentation will create excursions from that sample and our ability to identify and understand what caused the difference is enhanced.

- **Mission Activities** are the series or networks of activities that make up a mission thread show how the combination of people and activities accomplish a mission. These activities are captured in our process maps and in some of the architectural artifacts.

- **Supporting Systems and Networks:** Each mission activity suggested above may have supporting networks and systems to automatically execute those activities. Understanding where and to what degree activities are supported by information technology also enables us to find gaps in the network.

- **Modeling and Simulation:** Decision support models and simulation capabilities developed by SM 21 (Southern California Agile Supply Network Model, Multi-modal terminal model) or other organizations will be considered for incorporation into experiments. Any of the three SM 21 models currently being developed will be considered. Additional models for example, the NCOIC logistics interoperability model design using the JDDSP attributes will be considered.

B-6.2 Experimentation Framework (Structures, Processes, Procedures and Products)

The following is a summarized initial listing of the long term research/investigative objectives:

- Determine the level of improvement and accuracy in decision-making that would occur from having total asset visibility with the appropriate applications available in the JDDSP SOA.

- Identify the number of inputs and their frequency that could be successfully processed from all sensors and interfacing systems using a subset of the planned JDDSP portal.

- Map operational activities and processes to specific mission capabilities and systems support and determine network or system support gaps or duplications of system assets.

- Measure the shortened timeframe required to integrate information from three interoperable systems compared to their previous performance as individual point-to-point systems.

- Evaluate the effective RFID ranges and accuracies of container and unit identification level sensors and transceiver support networks that will enable successful collection of data and its transmission.

- Show the affects of well-designed models and their simulations on the quality of decision making regarding goods moving in and out of the JDDSP or other defined sub-networks i.e. Sea-Base.

- Link air/surface freight transportation and distribution systems with scheduled air, rail, and long-haul road carriers to determine the level of possible synchronization.

- Determine the level of improved performance from using a combination stow plan and load plan between the port of embarkation and the origin of the equipment movement.

- Find the acceptable level of performance each for class of supply considering the type of supply chain required to successfully process and deliver supplies.

- Stress specific systems such as ICODES and TCAIMS-II to determine their ability to be extended to air, sea, and surface load planning applications.

- Review potential physical domain improvements such as prototype smart containers being shipped from a DLA depot via CONUS rail or truck shipment to ports of embarkation to the ultimate destination.

- Evaluate the availability, time, quality of signal, and other parameters to establish voice and data communications where none had previously existed such as in an ad hoc network where the JDDSP might be employed.

- Investigate in transit nested visibility (rail car to rail car tracking) to test sensor devices and support systems for electronic seals, shock, temperature, etc.

- Introduce new innovations in products, services, and technologies such as the proposed Wave-Cam (SKYCAM) application and others for use in an appropriate experiment.

- Validate the correlation between the ship stow and load plan at the ports compared to the marshaling and staging plan developed for operational use at the JDDSP and point of origin.

- Test command and control yard flow management systems to be used for operations within the JDDSP and for operations that interface with activities at the port.

- Use the guidelines for sea-based requirements being provided by LMI to form the baseline for maximum goods flow metrics to the proposed sea-base via the port of embarkation.

B-7.0 Joint Community of Interest Network (JCOIN)

This community of interest is defined by government, academia, and the commercial stakeholders who share an interest in the global logistics network. This community represents potential JDDSP stakeholders and sponsors. At the federal government level, these stakeholders tend to be members of the Department of Defense and the Department of Homeland Security.

SM21 is working to identify specific organizations including but not limited to: USTRANSCOM, Defense Logistics Agency, Joint Forces Command, the Services, and selected Combatant Commands. SM21 is also working with State and municipal governments that also have a stake in the logistics capabilities of the JDDSP. Integrators and original equipment manufacturers such as Boeing, Lockheed Martin, Microsoft, Siemens, etc. have maintained an interest in this project.

B-8.0 Long Term Experimentation Approach

The SM 21 experimentation approach complements the network centric spiral development process which results in mission capability packages for approval by the JROC (Joint Requirements Oversight Council) via the JCIDS (Joint Capabilities Integration and Development System) process. Experimentation is used to inform design and engineering teams. Architects, designers, and systems engineers execute their work following the agile development engineering process. Requirements capture, architecture, standards, modeling and simulation, process mapping, information assurance, prototype development, test and experimentation, human systems integration, and recycle will all be supported using agile development processes. The first SM 21 experiment to be completed with the Dole Foods experiment will be used as an exploratory experiment to develop an experimentation template for use in other JDDSP related experimentation.

B-9.0 Strategic Framework (Related Exercises, Experiments, Wargames, and Programs)

There are a number of exercises, experiments, wargames, and program efforts external to SM21 that could have an impact or be used as a venue for further interoperability experimentation. These include but are not limited to CWID (Coalition Warrior Interoperability Demonstration); Trident warrior experimentation; AT 21 (Agile Transportation for the 21st Century) ACTD; JRAE (Joint Rapid Architecture and Engineering); MNE-5 (Multinational Experiment Number Five); Sea Viking ’07; NoMaDD (Node Management and Deployable Depot); Army Corps of Engineers Future Fort ACTD; JFCOM JFP (Joint Force Protection) ACTD; Autonomic RFID (MEC); BCS3 (Battle Command Sustainment Support System); JETA SPOD (Joint Enable Theatre Access Sea Ports of Debarkation); GCSS-J (Global Combat Support System – Joint); CFAST (Collaborative Force Building, Analysis, Sustainment, and Transportation); ILC (Integrated Logistics Capability); LOGCOP (Logistics Common Operating Picture); and others.

B-10.0 SM21 Joint Experimentation Campaign Plan investigation Threads

Eight investigation threads link the various planned experiments. All eight are viewed through the prism of the JDDSP Mission Capability Packages operative initially in the physical and information domains (and later cognitive and social domains). Joint context as set forth in the Quadrennial Defense Review will be reflected in traditional, irregular, disruptive and catastrophic scenarios as appropriate. Figure B-5 provides a visual overview of the eight investigative threads.

Figure B-5: SM 21 Experimentation Campaign Investigative Threads

- The first investigation thread is the investigation of the application of network centric warfare tenets in the focused logistics functional area. These include collaboration, data sharing, situation awareness (in a bi-directional sense commander's intent flow down and sense and respond logistics feedback loop), and network self-synchronization.

- The second investigative thread is the service oriented architecture (SOA) structure converting developed and proven capabilities to web services. This includes the development of program and experiment architecture and related artifacts (AV-1 all views, OV-1 Operational views, SV-1 System views, TV-1 Technical views etc). It incorporates the tenet of interoperability among stakeholders on a spectrum from data sharing, situation awareness, collaboration, self-synchronization, to eventual interdependency as an end state. It incorporates data reusability (metadata tagging, ontology, taxonomy). The SM 21 architecture will be operative in all four domains (physical, information, social, cognitive).

- The third investigative thread is the ubiquitous application and integration of multi-agent artificial intelligence to SOA and web services to advance from data to information to eventual knowledge based decision support. These elements include design ontology's to provide context to reusable data, defined agent domains, and rule based as well as heuristic agent protocols. Some of the capabilities expected to emerge from multi-agent services include dynamic re-planning, shipment intervention, and network dynamic healing.

- The fourth investigative thread is effects based operational analysis in a dynamic network environment. The hypotheses, scenarios and experiment design elements will all reflect the application of complex adaptive networks theory defining nodes and their attributes, arcs or relationships connecting the nodes comprising the network, actions or tasks directed at certain nodes, and measurement of impacts or effects (kinetic or non-kinetic) at the nodes using appropriate metrics of performance and effectiveness to the applicable domain.

- The fifth investigative thread is the Capabilities Portfolio Management Focused/Capabilities Based Logistics (FL/CBL) Functional Area including Rapid Deployment, Agile Sustainment, and Information Fusion. The attributes for each of these three are contained in strategic guidance set forth herein.

- The sixth investigative thread is supply chain management based upon the Supply Chain Reference (SCOR) Model. This is a measure of supply chain or distribution network integration within an enterprise or an entire network. One hypothesis of SM 21 is that supply chain management and SOA equals enterprise agility. For experimentation purposes value chain analysis of the evaluation of cost or service business process implications at each node in a network will be incorporated in SCM evaluation. Use of the SCASN business process simulation model and optimization algorithms is also included in this investigative thread.

- The seventh of the investigative threads is the evolution of sense and respond logistics methodology as a transformational paradigm to the art and science of logistics merging sensors (autonomic logistics) and interpretation of non-traditional demand signals to attain supply-demand equilibrium within a logistics network. SRL embodies its own unique attributes and measures of performance and effectiveness. The emphasis is placed upon interpretation as a decision support and eventually artificial intelligence based capability that converts data to information through the addition of context and eventually knowledge management.

- The eighth and final investigative thread is knowledge management again built on SOA architecture but with the objective being capture and reuse of modeling and simulation, relational data bases, lessons learned, and experiments outcomes for reuse, replication, adaptive planning, and execution performance feedback. It is in this thread that the thesis of SOA plus supply chain management integration as measured using the Supply Chain Reference (SCOR) model resulting in enterprise or network agility is tested.

The sum of the investigative threads is a self-synchronizing network capability in terms of unit of time, space and purpose.

B-11.0 JDDSP Experimentation Campaign Concept

The top level concept that drives the JDDSP experimentation is that commercial (COTS) and government off-the-shelf technologies (GOTS) can be integrated into a network of capabilities that will result in capability greater than the absolute sum of its parts. In the past logistics networks and systems-of-systems have been streamlined and optimized for maximum levels of performance with mixed results. SM21 plans to reduce the risk and enhance the chances of significance performance increases by developing a sound experimentation plan, which supports the integration and development process. The experimentation process will be supported by the scientific method of hypotheses design and testing. In the following paragraphs a summarized listing of the experimentation planning, development and design elements:

B-11.1 Initial SM21 Experimentation Planning Elements

- Develop Hypothesis
- Test Hypothesis
  - Develop Hypothesis Tree
  - Link Each Branch To A Relevant Experiment Or Test
  - Review The Relevance and Logic
- The Baseline Model
- The Experimentation Team
  - Experimentation Research Leader
  - Customer Process Owners
  - Subject Matter Experts
  - External Analysts
  - Observers
  - Hands-On Technicians
  - Prototype Developers
  - Facilities Owners
  - Trainers
- The Variables
  - Dependent
  - Independent
  - Intervening
- Comparison Baseline and Associated Treatments
- Sample Size
- Rough Experimentation Plan
  - Missions
  - Assets
  - Schedules
  - Boundaries
  - Contingencies
- Subjects
- Scenarios
- Observation/Data Collection
- Feasibility Review and Exploratory Modeling
- Experimentation Infrastructure
  - Controllable Influences
  - Exogenous Influences
  - Data Collection and Analysis Plan

B-11.2 Experimentation Plan Development Elements

- Total Set of Campaign Experiments

- Campaign Objectives
- Products and Implications of the Experiment
  - Residual Assets
  - Evaluation
  - Requirements for Acquisition
  - New Business Processes
  - Peer Review Plan or Independent Assessment
- Analysis and Evaluation Methodology
  - Control Variables
  - Documented Baseline for Comparison
  - Metrics and Data Collection Methods
  - Processes and Organizational Changes Considered
  - Data Collection Plans
    - Critical Indicators
    - Quality Control Processes
    - Reuse and Archiving
    - Standard Data Formats
    - Evaluation Plan
  - Models and Simulations
- Plan Experiment and Develop Experimental Architecture
  - Applicable Technical Standards, Protocols,...
  - Legacy System Enhancements
  - Configuration Management Process
  - End To End Architecture
- Facility Planning
  - Schedule of Facilities and Resources
  - Potential Conflicting Events
  - Disruption Avoidance Plan
- Training
  - Criteria and Required Standards of Proficiency
  - Training Plan and Program for Participants
- Security
  - Defense Information Technology Security Certification and Accreditation Process (DITSCAP) Compliance
  - National Information Assurance Certification And Accreditation Process (NIACAP) Compliance
- Risk Management
  - Types and Levels of Risk
  - Infrastructure
  - Personnel Availability
  - Funding
  - Schedule
  - Cost
  - Risk Mitigation Options
- Schedule Plan and Control
  - Critical Event Dependencies and Long Lead Items

  - Progress Reviews, Peer Reviews, Critical Decision Reviews
  - Hardware/Software/Infrastructure

- Design and Implementation Plan
  - Final Experiment Designs
  - Final Experiment Architecture
  - Data Collection Plan
  - Test and Integration Schedule
  - Infrastructure, Support Tools, Required Databases
  - Experiment Analysis and Evaluation Plan
  - Measures of Effectiveness, Metrics, and/or Success Criteria
  - Iteration and Entry/Exit Criteria
  - Security Policies

B-11.2 SM21 Considerations and Principles of Experimentation Design

- An experiment without good data is just a training exercise
- When designing the experiment, when is the right time to consider data collection and metrics evaluation?
- How do you link the experiment objective to data collection from the systems and simulations in the experiment using the future Joint Warfighting metrics listed in the Joint Operating Concepts (JOCs), Joint Functional Concepts (JFCs), and Joint Integrating Concepts (JICs) under the Conceptual Framework for Net-Centric Operations and the Net-Centric Warfare Tenets?
- How is the experiment's objective(s) linked to data collection and metrics evaluation?
- How is a testable hypothesis developed from the experiment objective?
- How are the dependent and independent variables determined and "operationalized"?
- The data collection requirement will dictate the number, type and qualifications of SMEs/data collectors and the quantity and type of instrumentation needed. What are the right types of data to be collected manually?
- How do you represent the analytical reports early in the experiment design process to ensure the desired results will occur?
- How should data collection and metrics evaluation be reported to be of most post-experiment value?
- How can data collection and metrics evaluation be applied to gain the most ROI for the customer?
- How do you achieve meaningful results within a time constrained experimentation cycle, i.e., rapidity of results? Are there methods to design activities that provide both a reasonable level of analytical rigor that can be conducted rapidly, and modified to address cycle constraints?
  - Methodologies and Tools
    - What tools are used as experimentation stimulators and why? What methodologies are used to analyze the data obtained during the experimentation?
    - How are qualitative assessments used?
    - What tools are used to report the results?

  - What methodologies are developed (i.e., analysis framework, process for developing operational threads, and toolsets)?
    - Are there any social science tools that can be used in experimentation? If so, how?
- Subject matter experts
  - The knowledge and experience that Subject Matter Experts (SME) bring to experimentation are powerful tools for increasing analytical strength and validity. Like all powerful tools, they must be employed properly, or they can do as much damage as good. SME provide knowledge that cannot be garnered in other ways, but they compete with all other assets for the resources of the sponsor. They have experience that can shed light on difficult issues, but may commensurately have interests that diverge from those of experiment's objectives. How do you balance the use of SME and other assets using the resources available to achieve the best possible result for your experiments?
  - How do you classify and compare the impact of SME knowledge and experience to the impact of other assets on the quality of your experimental results?
  - How do you manage the controlled and uncontrolled aspects of SME knowledge and experience with the design of your experiment?

- Live operators:
  - Like SME, using real operators in experiments both provides great value and offers great challenges. The knowledge, skills, and abilities of operators provide a rich context of millions of detailed conditions to an experiment that would otherwise not be available. Likewise, these conditions are for the most part uncontrolled and difficult to measure.
  - How do we account for the wealth of detail added to an experiment by the use of live operators? How do we rigorously assess the cognitive factors of concern?
    - What types of unique influences on performance that live operators have on an experiment add value to the results?
- Training and doctrine
  - How do you account for different aspects of DOTMPLF (e.g., level of training of participants versus actual anticipated users)?
  - What types of qualitative data should be collected to characterize human performance?
  - What are the social and cognitive domain metrics that should be captured?
  - How do you report these results?
- Evaluation
  - What kinds of data, metrics, and evaluation should be done for consistency among the steps and used to best support follow-on developmental and operational testing?
  - Data management. Types of data generated. Are the metrics comparable to initial work done during the concept phase?
  - What measures of effectiveness are being used in the contract phase as opposed to the concept phase?
  - What is the effect of cost on the experimentation process?

B-12.0 Testable Attributes

In devising the SM21 joint experimentation campaign and strategy, the program will take its strategic guidance from the Joint Operations Family of Concepts including the Network Centric Operations Joint Functional Concept warfare and Focused Logistics JOC's, the Joint Logistics (Distribution), SRL and Joint Sea Basing JIC's, and the attributes and suggested metrics contained therein. It will adopt the spiral concept development pathway from the Office of Force Transformation and now USJFCOM. We will build a little, test a little, and hopefully learn a lot.

SM21 will rely heavily on the joint logistics principles underlying the JDDE. The Joint Logistics principles are: responsiveness; flexibility/agility, sustainability, survivability/reliability and simplicity

SM21 will also seek to test attributes from the same sources and particularly both the Focused Logistics and SRL areas. Attributes are testable or measurable characteristics that describe an aspect of a system or capability include: capacity, visibility, reliability, velocity, and precision

B-13.0 SM 21 Joint Experimentation Campaign Plan

The purpose of the SM 21 Joint Experimentation Campaign Plan is to:

- Develop the initial operating through full operating capability of the JDDSP through incremental spiral development and the use of the experimentation process.
- Demonstrate the use of the JDDSP in satisfying the requirements of the Joint Logistics (Distribution), Joint Integrating Concept (JIC)
- Test and measure the ability of the JDDSP prototype to reduce distribution costs, limit regional congestion, mitigate negative regional environmental impacts, and increase goods throughput capacity utilization.

The joint experimentation campaign will be designed to test both the military and commercial utility of the JDDSP as a smart node in the JDDE through the use of multiple mission capability packages (rapid deployment, agile sustainment, information fusion, container import tracking and tracing, Joint Sea Base buffer sustainment etc).

11.1 Joint Experimentation Campaign Template

Figure B-6 represents the information feedback loop based on the joint experimentation process. It is encompassed in the dynamic information flow from data collection through modeling and simulation, experimentation, and replication to a knowledge management repository of the joint logistics knowledge derived from the execution of the joint experimentation campaign.

Figure B-6 also describes the use of business process modeling and simulation as the basis for development of a concept model, use of Uniform Modeling Language 2.0 and SYSMIL to create an executable enterprise architecture, and conduct of experimentation and data collection to validate the model. The model would produce artifacts to permit replication of multivariable experiments with changed variables. The model would capture the knowledge gained through modeling and simulation and experimentation automatically into a knowledge management repository to, among other purposes, support doctrine change recommendations and JCIDS acquisition.

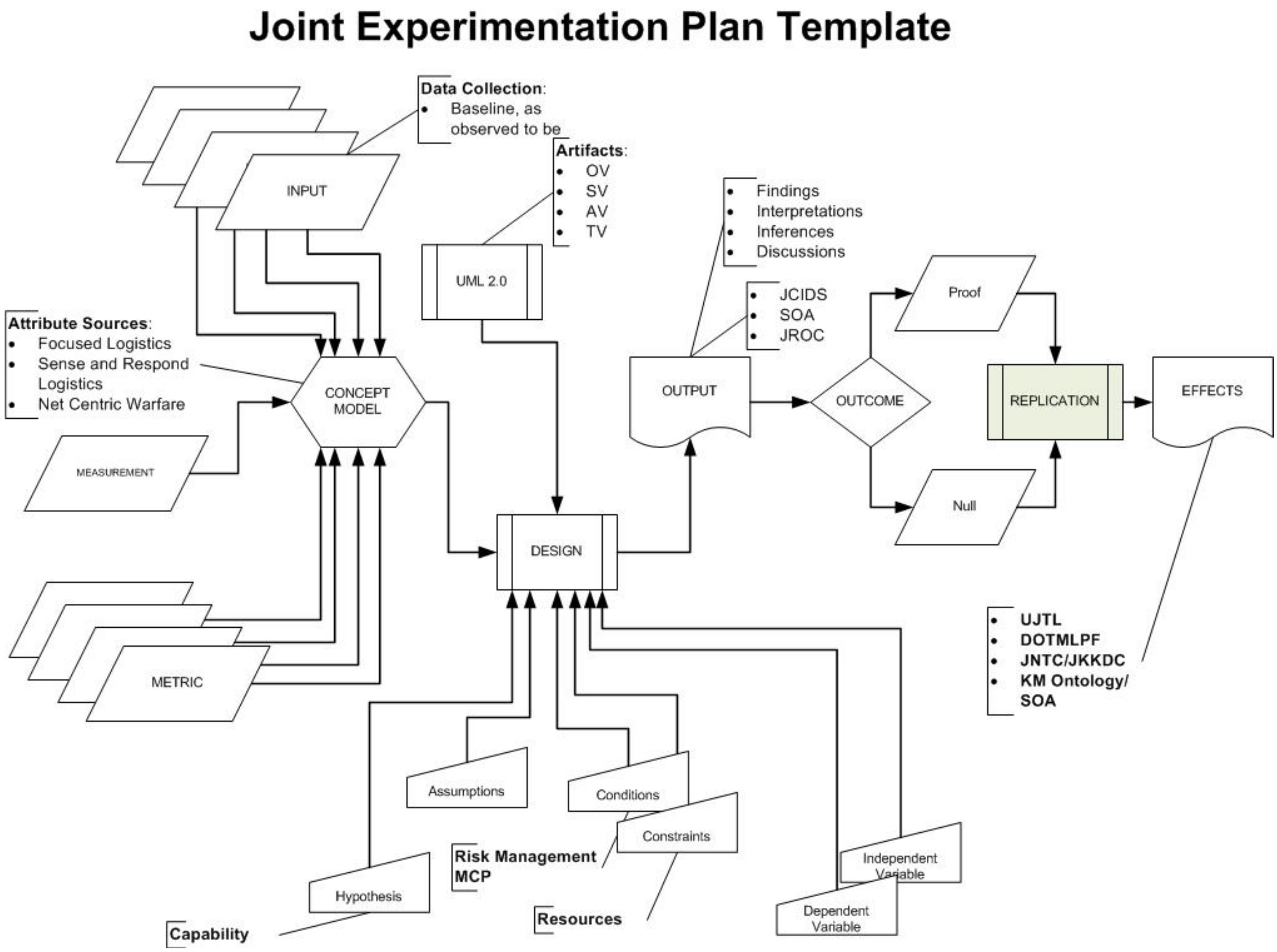


Figure B-6: Feedback Loop Conceptual Model through UML 2.0 SOA to Knowledge Management

APPENDIX C: Performance Based Evaluation Metrics

In evaluating the military utility of the SM2 1 JALTD capabilities, three interrelated elements will be employed:

- Critical Operational Issues (COI): These are high-level questions about accomplishment of the military and commercial tasks/demonstration objectives as well as systems operational tasks, essential capabilities, risks and uncertainties. COI do not have direct evaluation (parameters, objectives, or thresholds); rather, they ask the question that leads to the identification of direct evaluation criteria that have finite metrics.
- Measures of Effectiveness (MoE): A measure of the operational success that must be closely related to the objective of the military or commercial operation to be evaluated. A meaningful MoE must be quantifiable, objective wherever possible, and measure the degree to which the real objective is achieved. MoE measure task accomplishment.
- Measures of Performance (MoP): Reflects systems technical capabilities and may be expressed in systems engineering terms such as speed, payload, range, time on station, survivability, or other distinctly quantifiable performance features. MoP measure attributes needed for the task.

2.6.4 Critical operational issues and measures of performance and effectiveness

Critical operational issues (COI's) such as the extent of information sharing in an operational environment can have a critical impact upon the outcome of joint experimentation and the transition of capabilities.

Measures of performance measure the outcome in the success or failure of the experiment. Measures of effectiveness measure the outcome in the operational end state of the experiment. Table C1 provides a point of departure for MoE/MoP tailoring of use.

Critical Operational Issue	Measures of Effectiveness	Measures of Performance
Is the confidentiality of sensitive military and proprietary commercial data maintained at all level of users in the resultant system?	Provides information visibility to authorized viewers in a common workspace with 98 percent reliability.	There is no exposure of designated data elements to non-authorized users.

Can military operational logisticians (as required and authorized) have access to relevant force deployment and sustainment distribution information/data in order to make decisions that directly improve the deployment and sustainment flow?	Provides accurate visibility of installation and US transportation infrastructure in a common workspace for authorized users with 90 % reliability. Provides planned and executing deployment information related to the JDDSP for forces and/or materiel for a 72-hour future window in a common workspace with 95% reliability. Provides accurate in-transit visibility of material, to the discrete identifier level of data, from the point of origin (as defined during the "on-boarding" process) to defined logistics release point in a common workspace for authorized users with 95 % reliability.	The data representing the transportation infrastructure is refreshed on a near real time basis. Refresh period will be refined after the initial capability demonstration. The data capture mechanisms for military force deployment and distribution definition and transmittal permit creation and transmittal of requirements in a manner synchronized with the military and commercial operations. The data capture methods for military and commercial in-transit visibility provide timely refresh of data in a manner that fully supports the MoE.
Does the information connectivity within a military or commercial entity provide logistics information sharing in a manner that enhances distribution logistics interoperability?	Enables a capability that permits authorized users to transmit captured data to the military or commercial logistics interface definition within 5 minutes of system access. Enables a capability to provide accurate, refreshed, and relevant information to the defined military or user population in a common workspace with over 95% availability.	All the elements of transmitted data complete the transmission cycle within time parameters and are readable by the receiving system. The data elements employed to create decision-making information are updated with enough periodicity to ensure accuracy of information.
Do the data capture, data aggregation and data to information transformation methods provide the appropriate decision support for all authorized commercial and military users?	Receives transmitted data from respective military and commercial logistics systems and is capable of accurately performing the requisite data translation and aggregation to generate defined logistics information with 95 percent reliability.	Received data is capable of being transformed into relevant information without data format or content errors.

Table C1: MoE/MoP

APPENDIX D: Military Concept and Doctrine References

D-1.0 Overview

The development of the Joint Deployment and Distribution Support Platform will require a sound understanding of both Service and Joint logistics doctrine and concepts. This includes current and evolving transformational doctrine and concepts. To ensure the individual SM21 experimentation project team members are aware of the referenced documents, a document library and training program was initiated geared toward each individual experiment. While this information is readily available on the PMIS for all team members and selected external stakeholders, a brief overview of Sense and Respond Logistics and more extensive overview of the Joint Logistics (Distribution) Joint Integrating Concept are provided below because of their significance to SM21.

D-2.0 Sense and Respond Logistics

Sense and Respond Logistics is a transformational network-centric[30], knowledge-driven and knowledge-guided concept that sustains force capabilities packages to assure Joint and Coalition effects-based operations and to provide precise, adaptable, agile support for commander's intent. Sense and Respond Logistics relies upon highly adaptive, self-synchronizing, and dynamic physical and functional processes, employing and enhancing operational cognitive decision support. It predicts, anticipates, and coordinates actions that provide competitive advantage spanning the full range of military operations across the strategic, operational, and tactical levels of war. Sense and Respond Logistics promotes doctrinal and organizational transformation, and supports scalable coherence of command and control through functional integration of operations, logistics, intelligence, surveillance, and reconnaissance.

Implemented as a cross-service, cross-organizational capability, Sense and Respond Logistics provides an end-to-end, point-of-effect to source-of-support adaptive mosaic of logistics resources and capabilities. Within Sense and Respond Logistics, every entity, whether military, government, or commercial, is both a potential consumer and a potential provider of logistics. It delivers flexibility, robustness, and scalability for expeditionary warfare through adaptive, responsive, real-time, demand and support logistics within U.S., allied, and coalition operations[31].

The Sense and Respond Logistics metrics SM21 will reference for future related experimentation is provided on the SM21 PMIS, which were extracted from Operational Sense and Respond

[30] The definition of Network-Centric is currently moving toward Net-Centric. For SM21 Net-Centric is defined as the exploitation of advancing technology that moves from an application centric to a data-centric paradigm - that is, providing users the ability to access applications and services through Web services

[31] Operational Sense and Respond Logistics: Co-evaluation of an Adaptive Enterprise Capability, Sense and Respond Metric Overview, DoD Office of Force Transformation, Pre-release Draft located at: http://www.oft.osd.mil/initiatives/srl/family.cfm

Logistics: Co-evaluation of an Adaptive Enterprise Capability, Sense and Respond Metric Overview[32].

D-3.0 Joint Logistics (Distribution) - Joint Integrating Concept (JIC)[33]

The Joint Logistics (Distribution) Joint Integrating Concept calls for a joint deployment and distribution enterprise (JDDE) capable of providing prospective joint force commanders (JFCs) with the ability to rapidly and effectively move and sustain joint forces in support of major combat operations or other joint operations. This enterprise – an integrated system consisting of assets, materiel, personnel, leaders, organizations, procedures, tools, training, facilities, and doctrine – will provide logistics solutions to the JFC to minimize seams in the pipeline that characterize current strategic and theater distribution segments. The JDDE will complement, interact with and augment Service or JFC-unique distribution responsibilities and capabilities

The primary purpose of this concept is to support rigorous assessment and analysis of capability gaps and excesses through a Capabilities-Based Assessment (CBA) process in order to reach appropriate materiel and non-materiel solutions as part of the broader Department of Defense (DOD) Joint Capabilities Integration and Development System (JCIDS) effort. As the basis for performing this assessment, this concept will suggest a set of capabilities and corresponding tasks, conditions and standards that will potentially guide how a future JFC will integrate joint distribution activities into an overall campaign to enhance the conduct of joint operations. In addition, this concept is intended to help drive joint, Service, and multinational experimentation, and to influence science and technology efforts. When potential solutions are identified through the CBA, this concept will also inform the efforts of combatant commanders and others to improve current joint distribution capabilities.

The JIC describes a future, end-to-end JDDE and how the operation of that enterprise could enhance – rather than limit – the conduct of joint campaigns across the range of military operations in the period of 2015-2025. The mission of this future JDDE is to plan, synchronize, execute, and assess global joint distribution operations in support of JFCs. Joint distribution operations, as described in the context of this paper, provide for the movement or delivery of joint forces and sustainment from points of origin to points of need.

Joint distribution operations are a subset of the larger field of joint logistics. Joint logistics includes other areas such as acquisition and procurement; material maintenance, disposition/disposal/salvage of materiel; the construction, contracting, maintenance, operation, and disposition of facilities; health service support; civil and operational engineering; and the acquisition or furnishing of services (mortuary affairs, postal, disbursing, graves registration, etc.) and the necessary force protection to provide security for these functions. This concept does not explicitly address these other logistics areas. Clearly, however, joint distribution operations serve or enable these other logistic areas and provide a basis for them to be integrated into the JFC's overall concept for logistics support. It should follow from this discussion that the future

[32] Operational Sense and Respond Logistics: Co-evaluation of an Adaptive Enterprise Capability, Sense and Respond Metric Overview, DoD Office of Force Transformation, Pre-release Draft located at: http://www.oft.osd.mil/initiatives/srl/family.cfm
[33] Joint Logistics (Distribution) – Joint Integrating Concept, Version 1, 7 February 2006; located at: http://www.dtic.mil/futurejointwarfare/concepts/jld_jic.pdf

JDDE, as introduced above, would be an integral part of a larger, more encompassing joint logistics enterprise.

Follow-on joint concepts should address this larger logistics enterprise. Deployment, distribution, and sustainment capabilities are not the exclusive domain of joint logistics – these critical capabilities are also components of other broader operational processes, such as joint force projection. Joint force projection operations, for example, include the activities of mobilization, deployment, employment, sustainment, and redeployment.

While joint distribution operations include many similar tasks within the broader capability areas of deployment and sustainment, and other larger processes such as force projection operations, these terms should not be viewed to be synonymous. Joint distribution operations are only one facet, albeit critical, of these over-arching processes and materiel to desired operational areas. It encompasses all movement activities from origin or home station through destination, specifically including intra-continental United States, inter-theater, theater reception, intra-theater movement legs, and assembly areas.

It also includes global/intra-theater casualty and patient movement operations and support to non-combatant evacuation operations. Deployment implies the initial movement to or within the theater and may accomplish strategic or operational maneuver. In the context of this concept, distribution does not include those aspects of the deployment process involving decisions about self-deploying units, force readiness assessment, what units to deploy (sourcing), and priority of their deployment to satisfy JFC operational requirements.

As joint forces complete their deployment into the theater of operations they may be subsequently directed to conduct additional administrative or operational movements within the theater in order to be repositioned for follow-on missions. If these forces do not possess sufficient organic mobility assets to move themselves, then the JFC may employ common-user, intra-theater lift capabilities - theater movements of this nature are envisioned to be a key responsibility of the JDDE and, as such, are covered in this concept.

This concept also addresses agile sustainment as a key task of the JDDE. The timely and effective delivery (and return) of supplies, equipment, and services to the joint force requires a lean and agile supply chain. Joint distribution operations are inextricably linked to DOD’s global supply chain. Supply chain operations include materiel planning, sourcing, making, delivering, and return process activities. As in the case of joint logistics stated above, joint distribution operations directly support or influence supply chain planning, sourcing, making, and return activities.

The JDDE accomplishes the delivery function in support of DOD’s global supply chain operations. The supply chain must strike an optimal balance regarding inventory levels, the positioning of stocks, and the robust capabilities of a distribution pipeline that moves those stocks to and from the theater. It must also have the ability to expand to meet surge requirements or to support distributed forces in an anti-access environment. Finally, the supply chain must also coordinate sustainment distribution services among U.S. forces and host nation support (HNS), interagency (IA), multi-national partners (MN), non-government organizations (NGO) and contractors. This concept envisions a logistics system that is enabled by information technology advancements and superior distribution systems, with the capability to dynamically manage inventory flow within the pipeline to satisfy operational flexibility of the joint force and strike a proper balance between stock positioning and increased agile management of stock in the pipeline flow.

Joint deployment/distribution operations consist of moving forces and materiel from points of origin and sources of supply to final destinations or points of need with precision and speed.

A point of need is designated by the JFC. It can be a major strategic aerial or seaport of debarkation (A/SPOD), an austere airfield, a sea base, or any forward location within the battlespace (e.g., open fields, parking lots, highway segments, etc.). With real-time asset visibility, customers will be able to coordinate with the JDDE to influence the final destination that best meets their requirements. Current doctrine describes the joint distribution pipeline as being composed of two distinct segments. The first is the strategic segment that extends from the point of origin or sources of supply to a supported theater.

This segment supports two related functions: (1) traditional distribution functions currently performed primarily by the Defense Logistics Agency and the Services, and (2) transportation functions performed by U.S. Transportation Command (USTRANSCOM). The second segment is the theater segment that extends from the theater debarkation points to the final destinations or points of need within the theater. Operation of the in-theater portion of the joint distribution pipeline is currently the responsibility of the supported combatant commander. This concept addresses both of the segments described above, but does so within the context of a single, integrated joint enterprise that possesses sufficient authority to exercise selective control across the entire distribution pipeline.

D-4.0 Underling Logistics Principles

The logistic principles most critical to a successful deployment and distribution enterprise are: responsiveness, flexibility, sustainability, survivability, and simplicity. These principles should be used as a lens in which to examine potential capability proposals in follow-on capabilities-based assessments.

- **Responsiveness:** the right support in the right place at the right time. Among the logistics principles, responsiveness is the keystone. All other principles become irrelevant if logistics support does not support the commander’s concept of operations. Responsiveness is achieved by the enterprise if it can close, maneuver, reposition, sustain, and reconstitute Joint forces with a degree of rapidity, precision, and control to meet JFC requirements. Responsiveness of the supply chain must be measured from the customer’s perspective. In major combat operations, distribution responsiveness is most difficult to achieve during the seize-the-initiative portion of a joint campaign when the JFC may be required to conduct simultaneous, distributed, non-linear, and non-contiguous combat operations at the same time he is closing and sustaining the rest of his force. In the future, the responsiveness and operational reach of inter/intra theater mobility platforms will be measured in hours and days, not weeks and months. In order to meet responsiveness requirements of the follow-on “decisive-operations” portion of the campaign, the enterprise will be required to source and project standing, scalable, and expeditionary theater distribution capabilities in support of JFC requirements.

- **Flexibility:** the ability to adapt logistics structures and procedures to changing situations, missions, and concepts of operation. The ability to rapidly reposition or operationally maneuver joint forces is an example of the type of flexibility that the enterprise must possess to support fluid joint operations. The principle of flexibility also includes the concepts of alternative planning (e.g., branches and sequels), anticipation, reserve assets, redundancy, and centralized control and decentralized execution. Deployment/distribution plans and operations must be flexible to achieve both responsiveness and survivability. Flexibility will not be realized if the enterprise does not have near real-time visibility of customer requirements and support flowing to the customer. Deployment and distribution-related decision-support tools need to possess the ability to perform time-sensitive course of action, supportability, and risk assessment analyses in order to properly plan and react to changing missions and concepts of operation.

- **Sustainability:** the ability to maintain logistics support to all users throughout the area of operations for the duration of the operation. Lean supply chains will characterize future operations, placing critical importance on precise time-definite delivery of equipment and supplies to Joint forces throughout the battlespace. This principle poses the greatest challenge to the distribution enterprise since future forces will likely be highly distributed across greater distances with lines of communication that must connect non-linear and non-contiguous joint operating areas. A JDDE that is not fully networked with the customer and the supplier will not be able to see operational requirements in near-real time and will not be able to generate pipeline support, or manipulate the pipeline to adapt to changing operational priorities.

- **Survivability:** the capacity of the organization to protect its forces and resources. Distribution and other logistic units and installations are high-value targets that must be guarded to avoid presenting the enemy with a critical vulnerability. Survivability requirements present particular challenges to the enterprise in its mission to provide responsive and sustained distribution support to dispersed joint forces. Requirements for the protection of enterprise personnel, mobility assets, terminals, nodes (afloat and ashore), command and control centers, information, and lines of communication must be factored into the overall concept for logistics support for the joint force. Joint distribution operations may have to execute in an electromagnetic pulse (EMP) and chemical, biological, radiological, nuclear, and high yield explosive (CBRNE) environment. Force protection considerations will likely force the enterprise to continuously adjust route allocation, carrier selection, and scheduling activities, necessitating a robust set of decision-support tools and models to aid in planning and execution. The enterprise must also effectively address the protection of distribution capabilities sourced from commercial, non-governmental sources.

- **Simplicity:** this describes clear, uncomplicated, and concise orders, plans, and procedures that foster efficiency in both planning and execution of logistics operations.

Simplicity fosters efficiency in both planning and execution of logistic operations. Commander's intent, mission-type orders, and standard rules, tools, and procedures contribute to simplicity. Simplified procedures for establishing movement and issue priorities will greatly enhance joint distribution operations.

D-5.0 Associated Attributes:

Attributes are testable or measurable characteristics that describe an aspect of a system or capability. The attributes listed below best describe the critical characteristics required of an effective and efficient JDDE – collectively they serve as a basis for the development of standards that are explicitly linked to mission-essential tasks and supporting tasks.

- **Capacity**: defined by the physical quantity, size, mix, configuration, and readiness of the JDDE assets and infrastructure. Capacity is not a static attribute; it includes the flexibility to expand or contract enterprise elements in response to ever-changing missions and requirements.

- **Visibility:** the capability to determine the status, location, and direction of flow for all forces, requirements and materiel in the JDDE. Joint end-to-end visibility is required over operational capabilities and capability packages, organizations, people, equipment, and sustainment moving through the pipeline. It also includes the organic military mobility forces and commercial augmentation that move people and things through the pipeline, the financial transactions that support them, and the nodes and links comprising the pipeline. Visibility requires the availability of timely, accurate, and usable information essential to the maintenance of a common operating picture within the overall distribution enterprise information network.

- **Reliability:** the degree of assurance or dependability that the JDDE will consistently meet its support requirements to specified standards. Reliability instills trust and confidence of the customer in the certainty that the enterprise will meet warfighter demands under clearly established and recognized conditions.

- **Velocity:** the speed and direction requirements are fulfilled by the JDDE. Rapidity is only one aspect of velocity. Requirements must be fulfilled at the right speed. This means that synchronization of the speeds of the various aspects of the distribution process is required in order to maximize effectiveness. Velocity also incorporates the ability of elements of the JDDE to forecast, anticipate, and plan distribution execution. A JDDE that has sufficient velocity meets performance expectations and satisfies mission requirements as defined by the supported commander's concept of operations.

- **Precision:** within the JDDE this means the accuracy with which delivery of forces, requirements, and materiel occurs at the right time, the right place, and the right amount. Precision also addresses the ability of the JDDE to minimize deviation from acceptable standards as it reacts to dynamically changing conditions and requirements.

- **Shared Situational Awareness:** is the ability of leaders and personnel in the JDDE to understand and support the supported commander's intent.

D-6.0 JIC Recommendations for Joint Experimentation

The following are topical areas the Joint Logistics (Distribution) JIC recommends for joint experimentation:

- **C2.** Experimentation focused on command relationships among JFCs and the JDDE. Emphasis on the ability of the JDDE to plan and execute joint distribution operations needed to satisfy a supported commander's operational requirements, and organizational C2 elements and their relationships.

- **COP and Interactivity**. Testing to determine the quality (i.e., timeliness, accuracy, and reliability) of a net-centric enabled common operating picture. Emphasis on the ability of the JDDE to conduct interactive distribution planning and execution (both forces and sustainment) and the ability to conduct in-transit redistribution.

- **Financial Support Agility**. Experimentation focused on providing the DOD, the supported commander, and the commercial sector with a seamless and integrated financial capability that enables distribution/redistribution of scarce commodities without restrictions.

- **Future Lift Assets**. To determine an optimum configuration mix of lift assets needed to satisfy future distribution requirements, experimentation and analysis of alternate configurations of high-speed inter-theater sealift, high-speed intra-theater shallow draft connectors, ground transport capabilities (truck and rail), and inter/intra-theater airlift should be conducted. Recommend use of the operational demands derived from the SDTE mid-term MCO.

- **JDDE Protection**. Experimentation with alternate scenarios to determine effective protection measures against cyber and physical threats to the JDDE pipeline. Emphasis on determination of optimum balance between degree of protective restrictions and ease of operator access, protection effectiveness of information assurance and computer network defense, and cost.

- **Afloat Joint Reception, Staging, Onward Movement, and Integration/Intermediate Staging Base Capabilities**. Recommend testing of seabasing JRSOI/ISB capabilities to ensure theater reception throughput and enhanced operational agility. Place emphasis on the determination of the capacity of alternate afloat JRSOI/ISB configurations, application of modular platforms, and cost.

- **Multi-Echelon, Priority System**. Experimentation with the proposed multi-echeloned priority system to determine the feasibility of identifying supply priorities of a theater competing for scarce commodities, and the ability of the JDDE to satisfy theater requirements based on the multi-echeloned established priorities. Emphasis on the dynamic aspects of theater operations/redistribution and the capability of the JFC to update JOA support priorities and the JDDE to discern JOA priorities and redistribute critical in-transit commodities.

- **Predictive Analysis**. Conduct experimentation to further develop predictive analysis of sustainment requirements. Recommend emphasis on application of initial sense and respond logistics areas by the JDDE in support of the JFC.

APPENDIX E: 5QuadPod™ Technology

E-1.0 TECHNOLOGY

E-1.1 Materials

The project will include Alcoa Defense Systems and Bayer Material Sciences and other material providers to incorporate high impact strength, light weight and insulating properties into very thin-walled non-metallic constructs that can be laminated, pressed, and molded into multiple shapes and sizes. These new composites (see Figure D-1) will be compatible with the new RFID, sensor, and power harvesting/conservation technologies that are emerging and will enable these technologies to be embedded to provide dynamic real-time information or "Smarts" within these static materials.

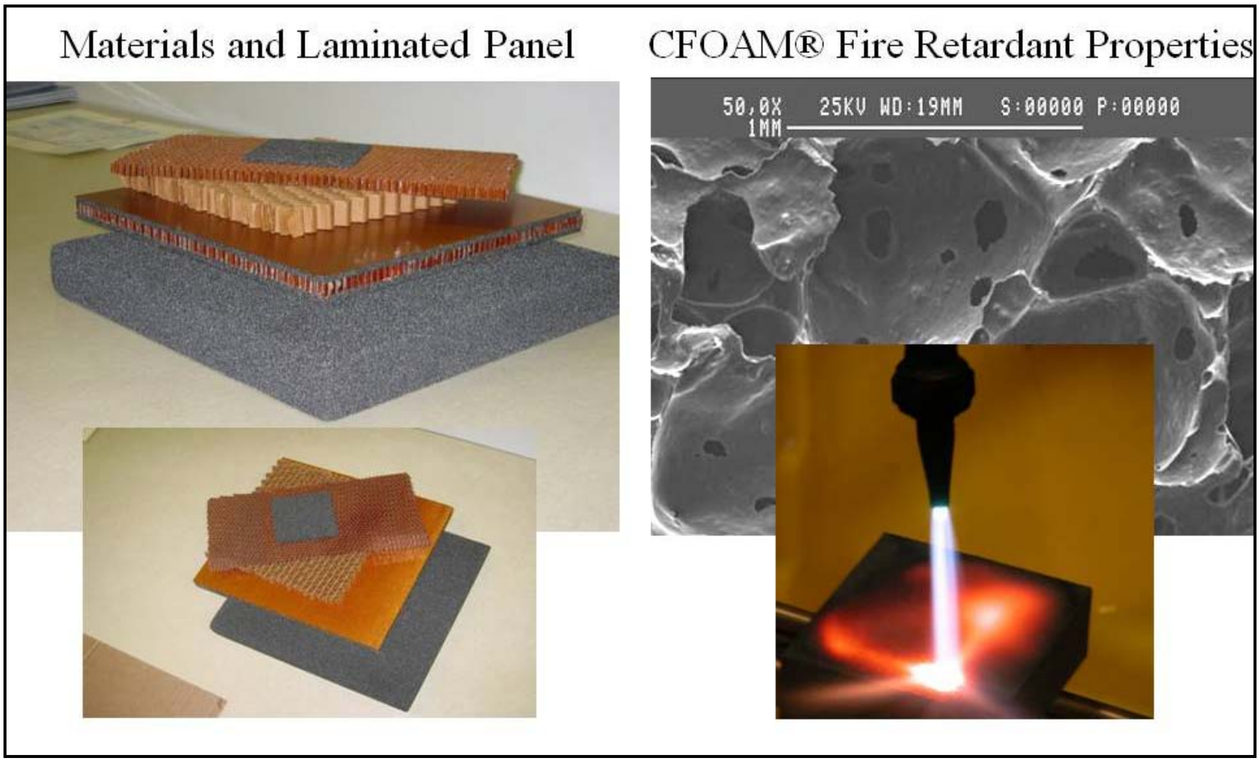


Figure E-1: New 5QuadPod Composites

Touchstone Research Laboratory has developed and is manufacturing a carbon foam material under the trade name CFOAM® that is a lightweight composite core material that can be easily designed into a multi functional sandwich panel. Touchstone has designed and tested a CFOAM blast-mitigating composite panel that absorbs high levels of impact energy. CFOAM is additionally fire proof and combining all of these properties into one panel design will be possible for numerous types of RFID shipping enclosures.

The porous micro structure of CFOAM makes it an energy-absorbing material. CFOAM is open-cell foam with pore sizes in the range of a few microns to a few hundred microns. The ligaments of the pores are capable of bearing structural loads.

CFOAM has high compressive strength and weight ratios. Its compressive strength is in the range of 200 psi to 3,000 psi with high energy-absorbing capability.

CFOAM is electrically conductive enough to be used as an effective shield for Electromagnetic Interference (EMI). A half inch thick CFOAM panel is capable of shielding greater than 80dB for the entire frequency range of 400MHz -18Ghz.

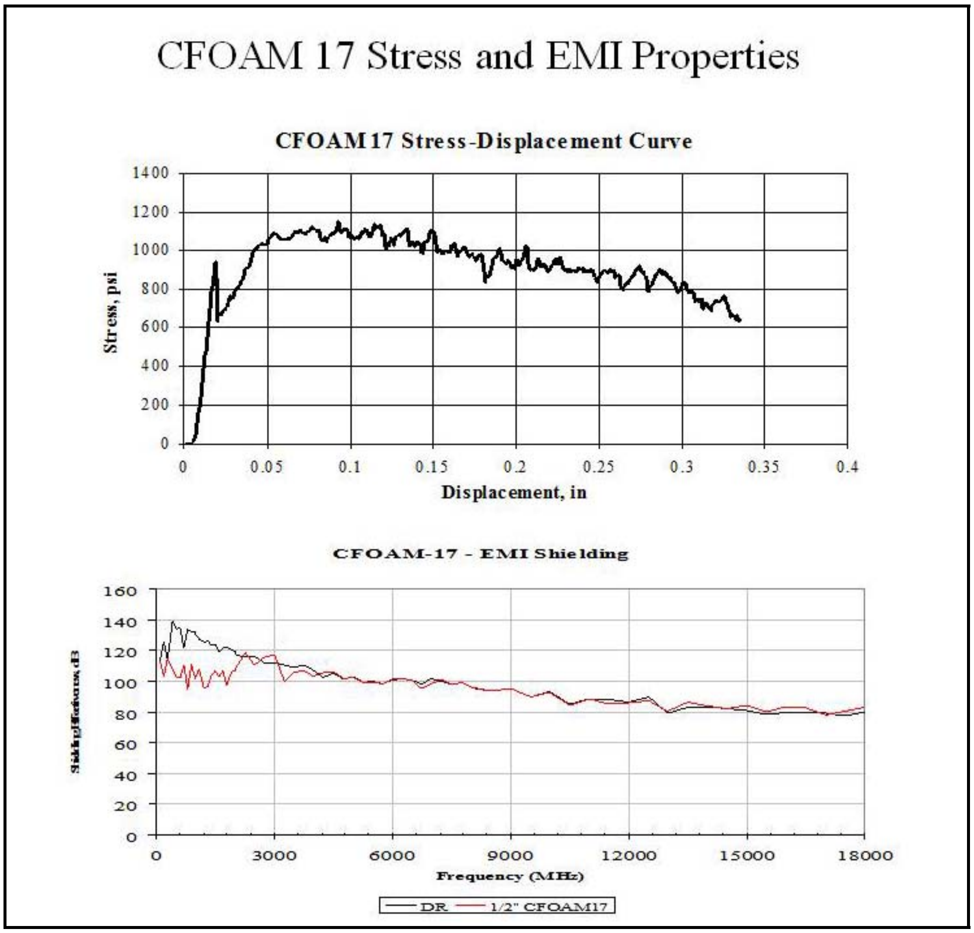


Figure E-2: CFOAM 17 Stress and EMI Properties

The two curves depicted above represent CFOAM and a solid aluminum plate. CFOAM proved to be equivalent to an aluminum plate in terms of EMI-shielding effectiveness in this frequency range.

Environmental Properties: Unlike metals, CFOAM does not corrode in a salt water atmosphere, has low galvanic activity, and demonstrates stability in a corrosive environment. Metals, even those with protective coatings, show severe corrosion after exposure to salt fog. CFOAM also will not support mold growth, a critical factor in marine and salt water applications. CFOAM exhibits tremendous fire retardant properties. It can sustain high temperatures after being exposed to 1650oC from an acetylene torch (see picture below). It is rated non-combustible and possesses the lowest flame spread index rating possible. Therefore there was no heat release, smoke generation or ignition detectable.

The CFOAM material has the ability to be machined, formed and laminated. It can be impregnated with various resins and reactive gels for ballistics and energy absorption, as well as provide a substrate for metallic flame spray techniques. It has a very low Coefficient of Thermal Expansion from -150^{o}C – 500^{o}C and has a service temperature of up to 450^{o}C. Testing has demonstrated CFOAM maintains 100% of its residual tensile strength after 2 million cycles at 90% ultimate tensile load, indicating significant resistance to fatigue loads and vibration.

Weyerhaeuser Honeycomb cardboard frame (Figure D-3 below) is utilized to form the core panel. The honeycomb is lightweight, provides air space and acts as a permanent anchor for the embeddable RFID antennae, sensors, RFID identification tags and laminates.

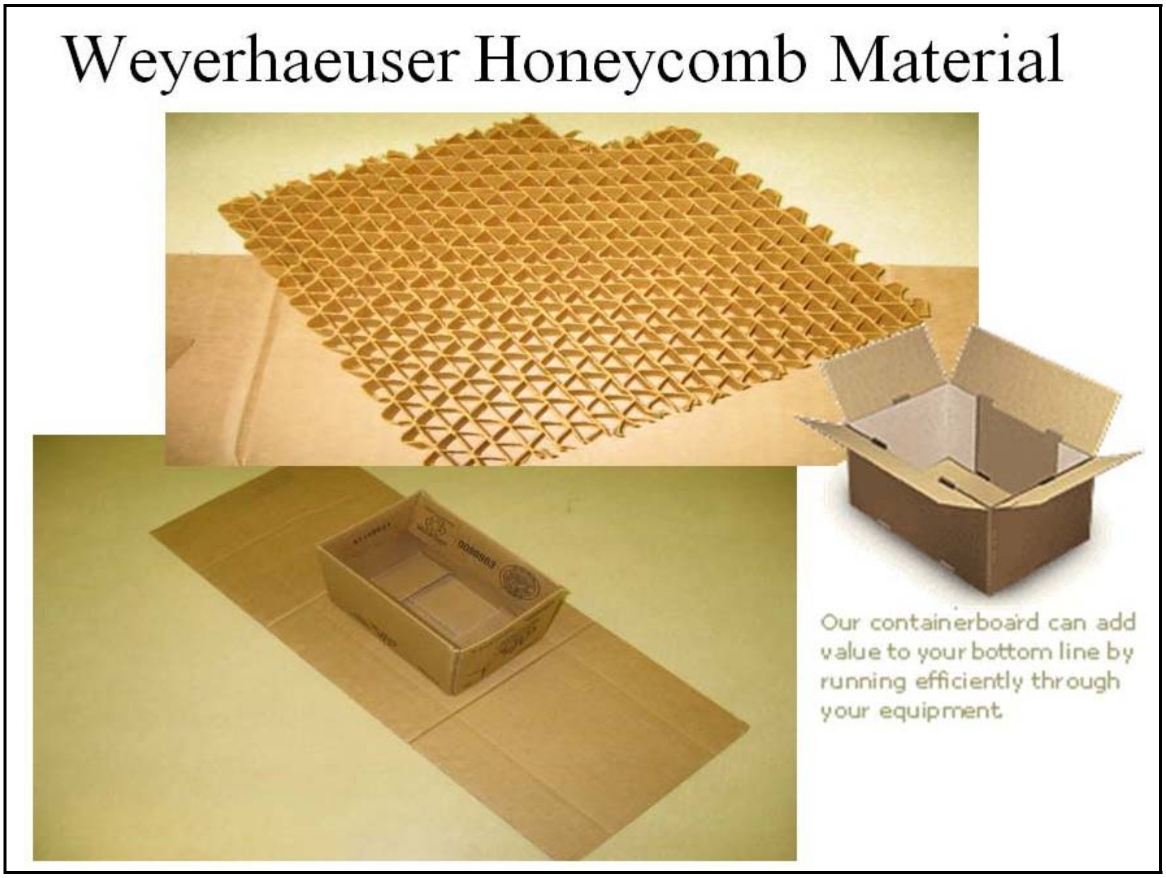


Figure E-3: Weyerhaeuser Honeycomb Material

E-1.2 Smart Technology

RFID is a non-contact technology, which provides a low-cost process to automatically identify a product; placement and orientation of a tag does not matter. Utilized effectively, the union of an RFID tag with product data can be used to actively track and monitor a product's location, usage status, expiration data and security. By combining RFID technology with application specific software, an Inventory Control System (ICS) can provide real-time inventory assessment, while creating automated customized reports that minimize the administrative workload associated with inventory control.

An RFID transponder (referred to as an "RFID tag" or "tag") normally consists of a silicon chip (EEPROM) bonded to an etched antenna (see Figure D-4). The silicon chip is the component that stores information. The antenna is then externally powered by an RFID interrogator and in sequence transmits the information from the chip over the air to the interrogator. These tags come in a variety of form factors for use in different environments, from fingernail size to 8.5 x 11 inches. The size of the tag will affect its read range.

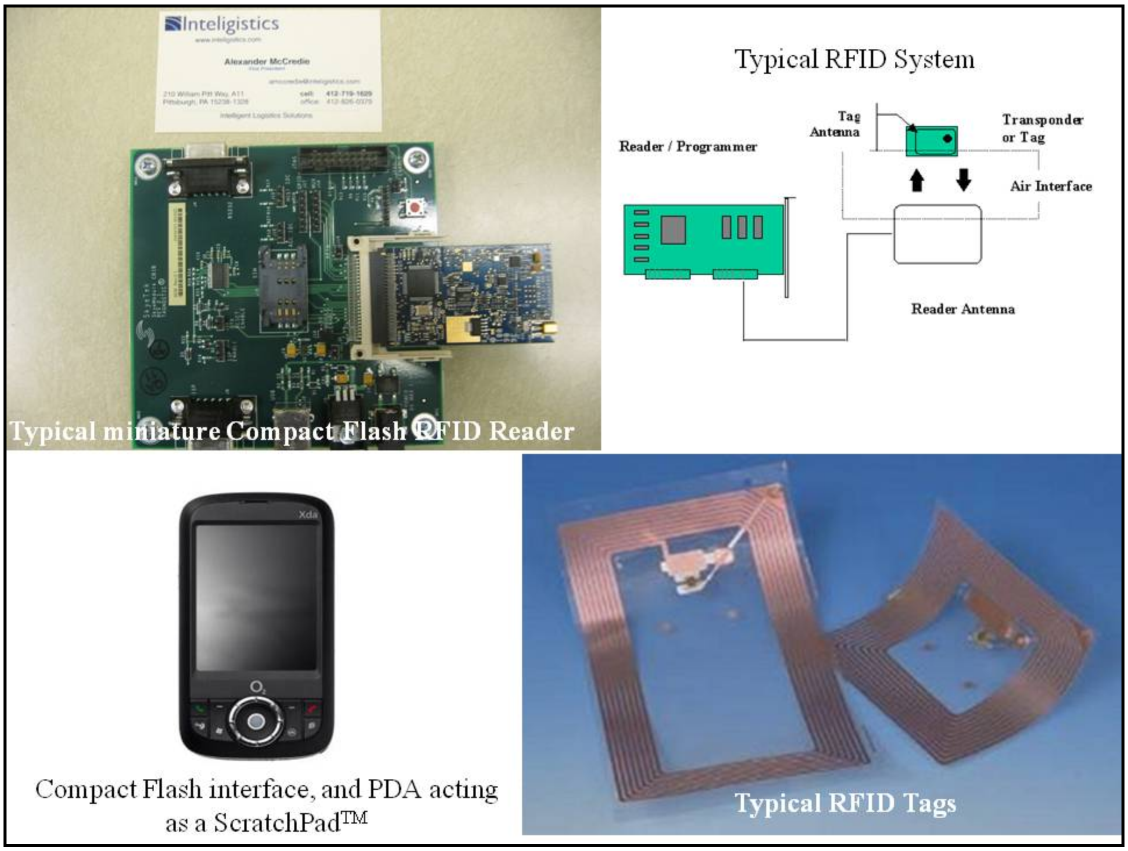
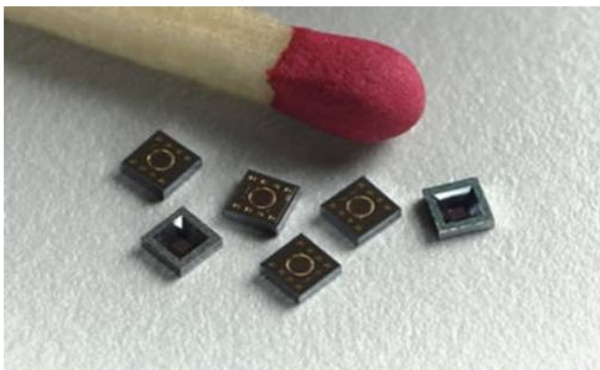


Figure E-4: Typical RFID Tags, Compact Flash RFID Readers, and RFID System

A typical RFID system consists of three major components – an RFID tag, an Interrogator Antenna, and an RFID Reader (see Figure D-4). On command, the reader powers the Interrogator Antenna, creating an electromagnetic field. Much like the tags, Interrogator Antennas come in many shapes and sizes, which affect read range and pick up rate. Normally, this field is constant to pick up any tags passing by it at any time. As the tag passes through the field, it is activated, and depending on the command of the reader, either sends its stored information over the air to the Interrogator Antenna, or is programmed. When the tag is commanded to send its stored information over the air, it is received by the Interrogator Antenna and then forwarded to the RFID Reader. The RFID Reader then decodes the Radio Frequency Signal. Typically, the RFID Reader is then hooked up to an Information System backbone, to which it transmits the information from the tag.

Unlike the bar code, the RFID tag does not have to be in the line of sight of the reader. This feature brings several advantages over existing methods for identification. First, no manual scanning or data entry is required to identify the object for processing. This occurs automatically, enabling personnel to focus their efforts on the delivery. Second, multiple items can be read in one scan. Finally, RFID is much more durable than bar codes. Because of its non-line of sight nature, RFID labels can still be read, if covered by dirt or grease.

Inteligistics is exploring the use of RFID readers that use the CompactFlash interface (see Figure D-4). These readers can be plugged into a PDA or smart phone to transform it into a real-time data acquisition device (see Figure D-4) or ScratchPad ™ like used in the DSB. The miniaturized readers are small enough to be embedded in an array of materials for tamper-proof installation.



A cluster of MEMS-based microphones. (Photo Courtesy of Em Kay)

How GPS tracking works (Source: http://www.cybergraphy.com/English/gtrack.htm)

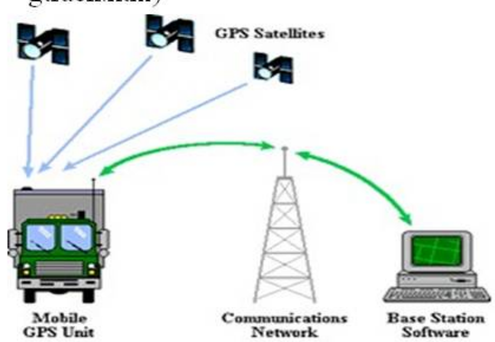


Figure E-5: GPS Tracking Technology

Another substantial feature of RFID technology is its read/write capability and its storage capacity. Unlike the bar code, from which a static “license plate” number can be read, information can be written to the chip embedded in the RFID tag. This enables the tag to act as a local, portable database that travels with the item. This capability allows a simple architecture to be designed, since an interface into a master database is not required with every read. SENSORS are required to gather information about the environment for chain-of-custody and cold-chain applications. Cold-chain applications monitor the goods being shipped and make sure

that environmental limits of those goods have not been reached during its voyage. In cold-chain applications, you are usually concerned with temperature, but other factors can also affect a product's use during and after transport. Vibration and pressure can also have an impact on the quality and life of a product, for example, blood products and medical reagents.
There are many sensors available. Sensors of interest for this project use Micro-Electromechanical Systems- MEMS (see Figure D-5). They use a combination of microelectronics and tiny mechanical systems to measure variables. For example, an accelerometer would use a tiny cantilever beam and mass system, combined with a differential capacitor to measure acceleration. MEMS have been used in many different applications; the most prevalent would probably be airbag deployment in automobiles.

Internet Connectivity and GPS are other technologies to consider. In order to track cargo remotely, both GPS and some kind of Internet connectivity are needed. The Global Positioning System- GPS (see Figure D-5) uses a receiver to receive location information from GPS satellites. The receiver can triangulate its own position. In order to relay the container's position to somewhere other than the GPS receiver, there will need to be some kind of embedded link to the outside world. In the case of cargo, that link has to be wireless so the GPS signal moves with the cargo. Via satellite and cellular links GPS signals, along with other data collected from data-acquisition devices, (embedded RFID and sensors) can be transmitted to anywhere on the globe.

APPENDIX F: Evaluating Commercial Supply Chain Agility

F-1.0 Overview

The transformational goal of the SM21 joint experimentation campaign for developing the hybrid dual-use JDDE construct is to improve business agility. Distribution and business agility is achieved through a synthesis of an agile Service Oriented Architecture and supply chain or distribution network analysis with improvement measured through the application of the Supply Chain Reference (SCOR) Model and Value Stream analysis.

A linear supply chain or a multi-vector distributed distribution network can be views as a series of linkages. It includes organizations and processes for the acquisition, storage, and sale of raw materials, intermediate products, and finished products. Supply chain product flow is linked by physical, monetary, and information flows. A supply chain perspective is from that of the manufacturer of supplies. A distribution network perspective is focused on the "deliver" function of the supply chain. Supply chain management represents expansion into a company-spanning planning and control strategy, inherently connected with IT support.

The SCOR model is comprised of several business process types and processes. The SCOR model is equally applicable to commercial and military supply chains or distribution networks. Remember DoD is committed through its Focused Logistics Joint Operational Concept and Joint Logistics (Distribution) Integrating Concept to logistics transformation through the development of a single logistics enterprise. The SCOR model is the best determinant of integration within the business or network with suppliers or distributors.

- Process Types:
    1) Planning
    2) Execution
    3) Enable (Infrastructure).
- Processes:
    1) Plan
    2) Source
    3) Make
    4) Deliver
    5) Return

F-2.0 Adaptive Supply Chain or Distribution Network

An adaptive or agile supply or distribution network is one which:

- Provides a cohesive process infrastructure connecting network participants, provides visibility, and monitors for changing conditions
- Integrates flows of information among diverse parties by means of information technology
- Incorporates a four-stage process:
  1. Visibility – exchange information among partners
  2. Supply chain community – execute transactions via portals

3. Collaboration – exchange customer requirement information
4. Adaptability – reduce process time, eliminate redundancies, introduce new products, etc.

The four stage process is indicative of a single entity or enterprise. The end state goal of a regional distribution network must be interdependency. The Southern California Agile Supply Network (SCASN) business process model is first step in this direction.

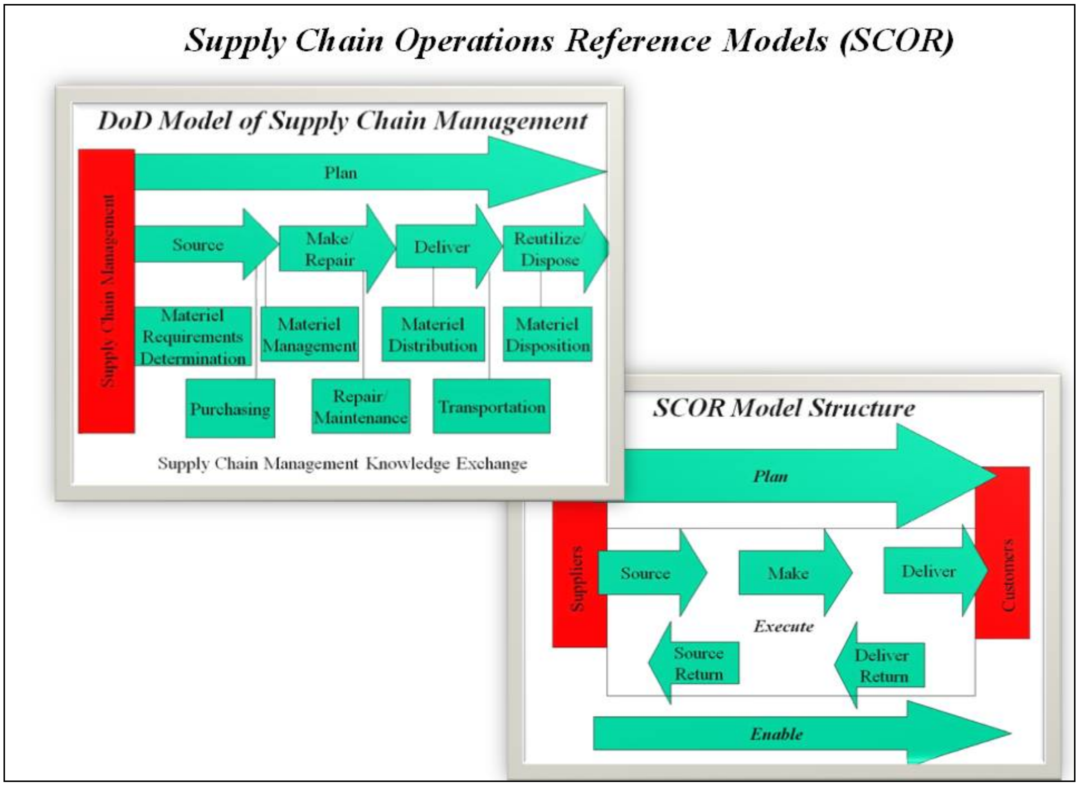


Figure F-1: The SCOR Models

F-4.0 Syllogism

If an Enterprise Architecture defines the As-Is and To-Be states for an entity, and a SOA is an orderly process for translating proven capabilities into services, and supply or distribution chain management represents a methodology for integrating an enterprise with the results measured in agility, then the essence of an experimentation campaign is to demonstrate agility. Stated differently, the desired end state or outcome for DoD logistics transformation in the form of the JDDE, or a commercial network, i.e. Southern California Agile Supply Network, must inherently follow the same four step path to business agility with results measured in the SCOR model and value chain analysis. The end state of a truly dual-use network is an adaptive distributed logistics network that has the ability to support both the commercial and military sectors that are employing adaptive distributed operations, which is the goal of Focused Logistics.

F-5.0 Logistics Business Process Perspective and Attributes

The same attributes used in the Focused Logistics context apply in the commercial SCOR and value chain setting.

- Logistics Chain Reliability: Performance of the logistics chain in negotiating and delivering shipments of the requested product/service, to the correct place, at the right time, in the right quantity, in the correct condition and packaging, with the correct documentation, to the correct customer (Perfect Order Fulfillment).

- Logistics Chain Effectiveness: Logistics ability to deliver optimized logistics support

  - Logistics Chain Capacity: Capacity of the DoD Logistics Chain to support demand
  - Logistics Chain Cycle Time: Time it takes the logistics chain to complete the logistics cycle, beginning at request and ending at delivery or closure
  - Supply Chain Response Time: Supply chain's ability to change rapidly in response to changes taking place in the organization's environment

- Logistics Chain Cost-Effectiveness: All direct and indirect expenses associated with operating logistics processes across the DOD logistics chain

  - Total Supply Chain Management Costs: All expenses (direct and indirect) associated with the supply chain including execution, administration, and planning
  - Value Added Productivity: Cost and productivity performance required to realize product revenue objectives
  - IT Cost Effectiveness: Percent increase in percentage of Logistics IT spending to total DoD business IT spending (year to year).

F-6.0 Innovation and Learning Perspective and Attributes

- Innovation Realization: Level of success with meeting innovation goals.

- Rate of Improvement: Rate at which initiatives have an effect on the performance of the supply chain cycle times, quality, productivity, and costs

- Innovation Ratio: Ratio of legacy processes and systems to FLE-aligned processes and BEA compliant systems

- Enterprise Integration: Level of integration across the DoD logistics architecture.

- Workforce Adaptability: Human interface adaptability to modernized systems and improved processes. Captures rates of training, and system/process acceptance

- Process/System Acceptance: Human interface adaptability to improved processes and modernized systems. Captures rates of process/system acceptance

- Rate of Training: Rate of training and training days.

GLOSSARY

Terminology	Definition
ACSA	Acquisition & Cross Servicing Agreement
ACTD	Advanced Concept Technology Demonstration
AIS	Automated Information Systems
AIT	Automatic Identification System
AMC	Army Material Command
APOE	Aerial Port of Embarkation
ASD NII	Assistant Secretary of Defense for Network & Information Integration
AT 21	Agile Transportation for the 21st Century
AV	All Views
BCS[3]	Battle Command Service Support System
BEA	Business Enterprise Architecture
C-TPAT	Customs and Trade Partnership Against Terrorism
CBA	Capabilities Based Assessment
CBP	Capabilities Based Planning
CFAST	Collaborative Force Building, Analysis, Sustainment, and Transportation
CHCP	Container Handling Cooperative Program
CHP	California Highway Patrol
CIN C	Commander in Chief
COA	Courses of Action
COCOM	Combatant Commander
COI	Critical Operational Issues
CONOPS	Contingency Operations
CONUS	Continental United States
COTS	Commercial off the Shelf
CTO	Chief Technical Officer
CWID	Coalition Warrior Interoperability Demonstration
DAC[2]	Dynamic Adaptive Command and Control
DCR	DOTMLPF Change Requirement

Terminology	Definition
DFW	Dallas Fort Worth
DITSCAP	Defense Information Technology Security Certification & Accreditation Process
DLA	Defense logistics Agency
DoD	Department of Defense
DOTMLPF	Doctrine, Organization, Training, Material, Leadership & Education, Personal, and Facilities
E to E	End to End
EUCOM	European Command
FLJFC	Focused Logistics Joint Functional Concept
FLE	Future Logistics Enterprise
FLOCTOC	Future Logistics Operational Capability Technical Operations Center
FSSC	Fleet Supply Support Command
GATES	Global Air Transportation Execution System
GCCS	Global Command Support System
GCSS	Global Combat Support System
GIG	Global Information Grid
GOTS	Government off the shelf
GTN	Global Transportation Network
GWOT	Global War on Terrorism
HNS	Host Nation Support
IA	Interagency
ICD	Initial capabilities Document
ICODES	Integrated Computerized Deployment System
ILC	Integrated Logistics Capabilities
IP MTOPS	Inland Port-Multi-modal Terminal Operating System
ISB	Intermediate Staging Base

Terminology	Definition
ISR	**Intelligence, Surveillance, and Reconnaissance**
ITS	**Intelligent Traffic System**
ITV	**Intransit Visibility**
J Ops C	**Joint Operations Concepts**
J – 4	**Logistics Staff Section, Joint Command**
JCIDS	**Joint Capabilities Integration & Deployment System**
JCTD	**Joint Concept Technology Demonstration**
JDDE	**Joint Deployment and Distribution Enterprise**
JDDOC	**Joint Deployment and Distribution Operations Center**
JDDSP	**Joint Deployment and Distribution Support Platform**
JDST	**Joint Decision Support Tool**
JETA - SPOD	**Joint Enable Theater Access Seaport of Debarkation**
JFC	**Joint Functional Concept**
JFP	**Joint Force Protection**
JFRG II	**Joint forces Requirements Generator**
JIC	**Joint Integrating Concept**
JIM	**Joint Intermodal Multinational**
JLETT	**Joint Logistics Education Experimental Training Test Bed**
JLOTS	**Joint Logistics Over the Shore**
JMMR	**Joint Monthly Readiness review**
JOA	**Joint Operational Area**
JOC	**Joint Operation Concepts**
JOPES	**Joint Operations Planning and Execution System**
JRAE	**Joint Rapid Architecture and Engineering**
JROC	**Joint Requirements Oversight Council**
JRSOI	**Joint Reception, Staging, Onward Movement, and Integration**
JT LOG C^2	**Joint Logistics Command and Control**

Terminology	Definition
JTAV	**Joint Total Asset Visibility**
JTL	**Joint Theater Logistics**
JV	**Joint Vision**
JWCA	**Joint Warfighting Capabilities Assessment**
JMSR	**Large Medium Speed Roll on / Roll off**
LOGCOP	**Logistics Common Operating Picture**
MAGTF	**Marine Air Ground Task Force**
MCB	**Marine Corps Base**
MCO	**Major Contingency Operations**
MEF	**Marine Expeditionary Force**
MN	**Multinational**
MNE – 5	**Multinational Experiment – 5**
MoE	**Measure of Effectiveness**
MoP	**Measure of Performance**
MOTCO	**Military Ocean Terminal Concord**
MUA	**Military Utility Assessment**
NATO	**North Atlantic Treaty Organization**
NAVSUP	**Naval Supply System Command**
NCEDS	**Net Centric Enterprise Services**
CNOIC	**Net Centric Operations Industry Consortium**
NCW	**Net Centric Warfare**
NEW	**Net Explosive Weight**
NGO	**Non Governmental Organization**
NIACAP	**National Information Assurance Certification & Accreditation Process**
NII	**National Information Infrastructure**
NoMoDD	**Node Management and Deployable Depot**
NORTHCOM	**Northern Command**
NTC	**National Training Center**
OCONUS	**Outside the Continental United States**
OCR	**Optical Character Reader**
OEM	**Original Equipment Manufacture**

Terminology	Definition
OEMS	**Order Entry Management Systems**
ONR	**Office of naval Research**
OV	**Operational Views**
PFC	**Protocol Functional Collection**
POLA	**Port of Los Angeles**
POLB	**Port of Long Beach**
RFID	**Radio Frequency Identification**
ROMO	**Range of Military Operations**
S & R	**Sense and Respond**
SCASN	**Southern California Area Supply Network**
SCLA	**Southern California Logistics Airport**
SCOR	**Supply Chain Reference Model**
SDDC	**Surface Deployment and Distribution Command**
SDTE	**Synchronous Data Terminal Equipment**
SIPERNET	**Secure Internet Protocol Router Network**
SM 21	**Strategic Mobility 21**
SME	**Subject Matter Expert**
SOA	**Service Oriented Architecture**
SOCAL	**Southern California**
SPG	**Strategic Planning Guidance**
SPOE	**Seaport of Embarkation**
SRL	**Sense and Respond Logistics**
STRACNET	**Strategic Rail Network**
STRAHNET	**Strategic Highway Network**
STRATCOM	**Strategic Command**
SV	**Service Views**
T-AKE	**Auxiliary Cargo (K) and Ammunition (E) Ship**

Terminology	Definition
TATRC	**Telemedicine and Advanced Technology Research Center**
TAV	**Total Asset Visibility**
TC AIMS II	**Transportation Coordinator Automated Information Management Systems**
TCOS	**Trade Corridor Operating System**
TD	**Theater distribution**
TEU	**Twenty Foot Equivalent Unit**
TSA	**Transportation Security Agency**
TTP	**Tactics, Techniques, and Procedure**
TV	**Technical Views**
UDOP	**User Defined Operating Procedure**
UJCL	**Universal Joint Capabilities List**
UN	**United Nations**
USA	**United States Army**
USCG	**United States Coast Guard**
USDOT	**United States Department of Transportation**
USJFCOM	**United States Joint Forces Command**
USMC	**United States Marine Corps**
USN	**United States Navy**
USTRANSCOM	**United States Transportation Command**
WPS	**Worldwide Port System**